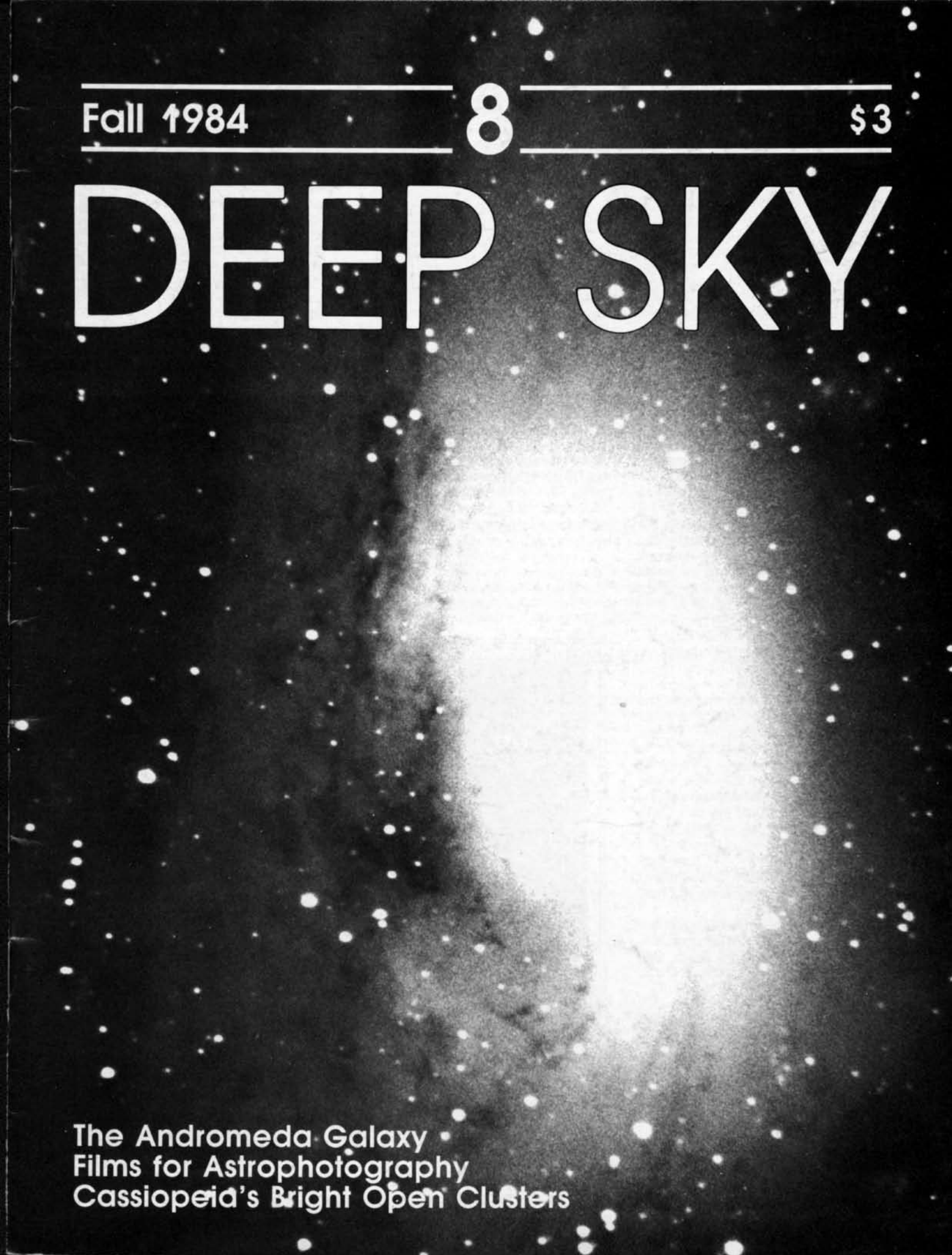
Fall 1984 8 $3

DEEP SKY



The Andromeda Galaxy
Films for Astrophotography
Cassiopeia's Bright Open Clusters

Letters to DSM

Finder Card Erratum

Dear Dave / I was generally pleased with the appearance of my article on finder cards in the Summer issue of *Deep Sky*, but you make me appear like a thief! It was John W. Kerns, not I, who originally thought up the idea for making the finder cards. Please print this letter and give someone credit who deserves it.

Dick Suiter
240 C. West 8th Avenue
Columbus, OH 43201

Binocular Telescopes

Dear Dave / In part one of the article "Observing Low Surface Brightness Objects" in the spring issue, my sketch of the Horsehead Nebula is captioned as being "made with a 13.1-inch f/4.5 Newtonian." The readers should know that the telescope was actually a 13.1-inch Newtonian *binocular*. Even on the excellent night when I made the sketch, I could not see the Horsehead through just one of the optical systems; using both mirrors, my brain could "integrate" the images and bring out the faint nebulosity. I used averted vision, and though I now know what to look for, I've failed seeing it on subsequent, less transparent nights. My binocular uses a third mirror, so sharp readers will note that my sketch is flopped relative to the photograph. The same night I made the sketch, another experienced observer, Logan Rimes, saw the nebula in my binouclar and in his 12.5-inch f/6 Newtonian. Through his telescope, I glimpsed IC 434, the little strip of emission nebulosity backlighting the Horsehead, but not the dark patch itself. I love *Deep Sky* — keep up the good work!

Lee Cain
16206 Grassy Creek
Houston, TX 77082

See page 32 in this issue for Richard Berry's article on Lee Cain's remarkable telescope and the 1984 Texas Star Party. — D.J.E.

Deep-Sky Achievement Award

Dear Sir / The Matrix, an Arizona-based fellowship of amateur astronomers, wishes to encourage deep-sky observing throughout the country by offering a deep-sky achievement award. Observers can receive the "pentallion," which fits onto any telescope, by viewing any 1000 RNGC objects with anytelescope. Upon completing 1500 objects, observers can receive a cluster which mounts in the center of the original award. For more information on the award and on the Matrix, contact the undersigned.

The Matrix
Box 10004
Phoenix, AZ 85064

An Observing Paradise

Dear Dave / In the spring of 1983, when I considered traveling to McDonald Observatory in Fort Davis, Texas, I wanted to take my own scope and make the most of the black Texan skies. And, being a deep-sky observer, I wanted a big telescope. But transporting a large telescope halfway across the country isn't what it's cracked up to be. I needed a solution. Why not, I reckoned, build an observatory adjacent to the Texas Star Party site so that a large telescope will be there and available to amateurs for all TSPs to come? After talking to the McDonald Observatory staff and the crew at the Prude Ranch (where the star party is held), I got the go-ahead.

I returned to my hometown of Birmingham, fabricated a 12-foot fiberglass dome, loaded up my van with a 16-inch Newtonian and spare parts, and went back to the Davis Mountains of Texas. The Prude Ranch people advised us that we could put this thing up on that 5300 foot peak on the ranch, right down the road from McDonald and within hootin' distance of Harvard's 85-foot radio telescope in the valley below.

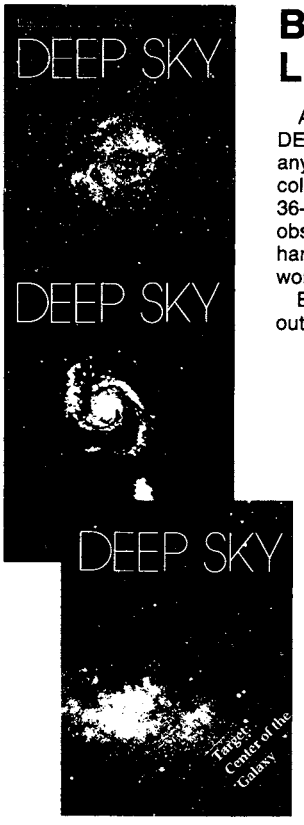
As the 1983 star party got underway, we dedicated the observatory to Edmond Halley. Our aim is to provide an amateur installation which can be used by any observers who happen to mosey on up the hill. Interested parties should write me a letter, drop it in the Pony Express, and wait for more information.

Ed Boutwell
720 South 23rd Street
Birmingham, AL 35233

What About Comets?

Dear Sir / I have been a subscriber to *Deep Sky* since the winter 1982 issue and I always enjoy receiving it. I am particularly happy when articles about faint deep-sky objects appear, like clusters of galaxies or large HII regions.

See Letters, page 4



Bring Your DEEP SKY Library Up-to-Date!

Are you a new subscriber? Did one or more of your DEEP SKY issues fall into a black hole? If you're missing any issues of DEEP SKY, here's your chance to keep your collection current — with DEEP SKY back issues. Each 36-page issue features informative articles on equipment, observing, technique and astrophotography, as well as handy maps, observing aids, sketches, and of course the world's most beautiful deep-sky photos.

Back issues are available for just $3 each ($4 each outside U.S.).

Send me the DEEP SKY BACK ISSUES I have checked ☑ below at $3 each ($4 each outside U.S.):

Enclosed is my check for $_____.

☐ DEEP SKY #1 ☐ DEEP SKY #4 ☐ DEEP SKY #5
☐ DEEP SKY #6 ☐ DEEP SKY #7

Name _____

Address _____

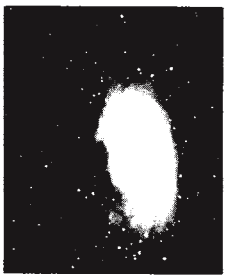
City _____ State _____ Zip _____

Send this coupon or a copy to: DEEP SKY Order Dept., 625 E. St. Paul Ave., P.O. Box 92788, Milwaukee, WI 53202.

DEEP SKY 8

The magazine for deep-sky observers and astrophotographers

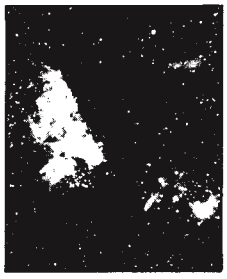
Fall 1984
Volume 2, Number 3

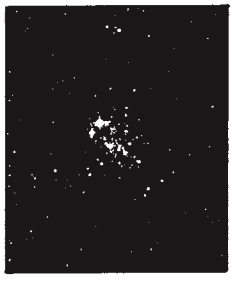


Cover: The core of M31, photographed by Paul Roques; 10-inch f/10 SCT, hypersensitized TP 2415, 85-minute exposure.

p. 8

p. 16





p. 22

Founder and Editor
David J. Eicher
Senior Editor
Robert Burnham
Managing Editor
Katherine Bond
Production Manager
Jane B. Lucius
Contributing Editors
Richard Berry
Glenn F. Chaple, Jr.
Alan Goldstein
Phil Harrington
David Healy
David H. Levy
James E. Meketa
Francis Reddy
Brian Skiff
Harold R. Suiter
Production Assistant
Mary MacAdam

President, AstroMedia Corp.
Robert A. Maas
Art Director
Thomas L. Hunt
Advertising Coordinator
Dana-Lynne Terry
Circulation Director
Kristie Fischer
Circulation Manager
Rosemary L. Pickart

8 All About M31

by Brian Skiff

M31, the Great Galaxy in Andromeda, is our sister spiral in the Local Group of galaxies and is one of the brightest, largest, and most observed of all deep-sky objects. Many observers casually look at M31 with their telescopes and then move on to fainter, "more challenging" stuff. But M31 is an object which can be studied in great detail. For small telescopes, it offers evidence of a galaxy's spiral arms; for large telescopes, it offers a look deep inside another spiral galaxy, complete with spiral structure, star clouds, globular clusters, and a brilliant, pinpoint nucleus.

16 Films for Deep-Sky Photography

by David Healy

During recent years, a virtual flood of new films hit the consumer marketplace. Which are good and which are bad for astrophotography, and why? Veteran astrophotographer David Healy answers these questions beginning on page 16, and suggests successful exposure times for recording the feeble light traveling from galaxies and nebulae.

22 Cassiopeia: Realm of the Star Clusters

by James Garasich

If you live in the Northern Hemisphere and are thinking about finding open star clusters, you're probably thinking about Cassiopeia. This rich section of Milky Way is cluttered with groups of stars of all types — bright, faint, distant, close, loose, rich — and provides an excellent hunting ground for the relatively young stars riding on the disk of the Galaxy. This article presents 37 of Cassiopeia's best.

2 Letters to DSM
The observers speak

7 Inside View
My Friend in Andromeda

30 DSM Reviews
Find a Possible Supernova
Telrad Finder Sight

32 DSM Reports
Seeing Double at the Texas Star Party

35 Double Stars
Exploring Andromeda in Autumn

37 Variable Stars
Ode to Autumn

38 Scanning the Literature

DEEP SKY magazine (ISSN 0735-3073) is published quarterly by AstroMedia Corp., 625 East St. Paul Ave., Milwaukee, WI 53202. Copyright © 1984 by AstroMedia Corp., all rights reserved. Material in this publication may not be reproduced in any form without written permission. Second class postage paid at Milwaukee, WI. POSTMASTER: Send address changes to DEEP SKY, P.O. Box 92788, Milwaukee, WI 53202. Direct all inquiries, complaints, editorial submissions, and other correspondence to the above address, telephone (414) 276-2689. The opinions expressed in this magazine are not necessarily those of the publisher or editors. AstroMedia Corp. cannot be responsible for unsolicited materials. Names and addresses of authors may be printed unless specifically requested otherwise. Questions about subscriptions: **(414) 276-8547**, weekdays 8am.-4pm. Subscription price (U.S.): 1 year $10, 2 years $18.50, single issue $3; (elsewhere): 1 year $14, 2 years $26.50, single issue $4. Clubs and dealers: inquire about bulk rates. Staff: Diane Kendzie-Holdaway, Karen Koeffler, Judy Peters, Susan Poole, Sandy Timmons, and Debbie Wicentowski. Film production: Mitchell Colorgraphics, Inc., Madison, WI. Printing: Eagles Printing, Eau Claire, WI.

Astronomy magazine © 2008 Kalmbach Publishing Co. This material may not be reproduced in any form without permission from the publisher. **www.Astronomy.com**

The Wonders of Cygnus

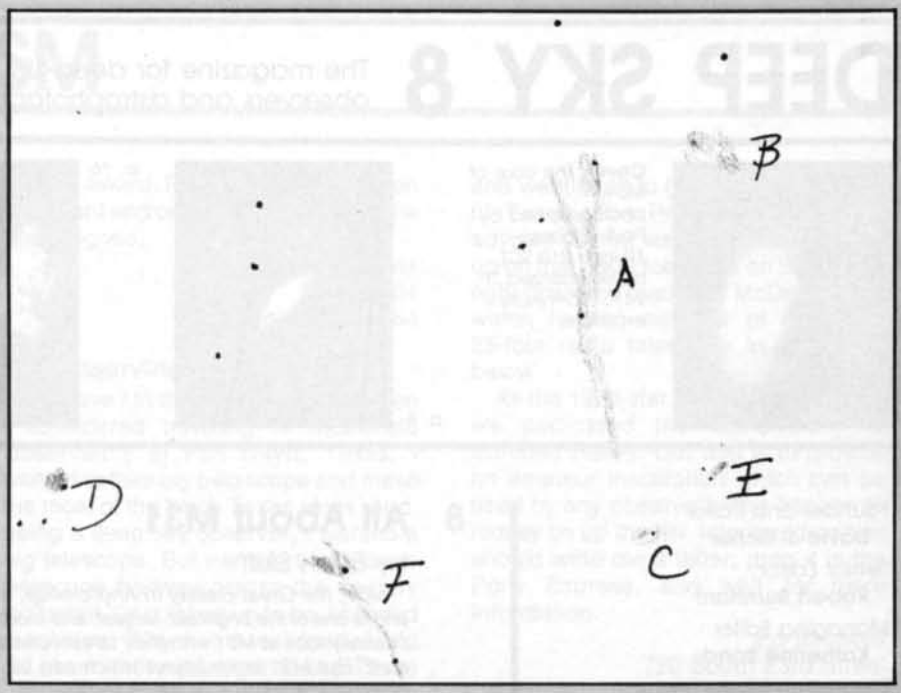
Dear Dave / I just finished a four-year telescope making project last spring and got my 12.5-inch reflector going in time to look at the nebulosities of Cygnus. When I observed Cygnus, I didn't yet have a finder telescope mounted on the 12.5-incher, so I decided to go looking for the Veil Nebula by sighting right up along the tube. I came across 52 Cygni and found NGC 6960, which looked bright with dim extensions well beyond what I was used to seeing with my 8-inch f/6 reflector. I also saw the dim triangular patch in the middle of the loop, and swept over to find NGC 6992/5 on the eastern side. At 75x, using one of those war surplus Erfles, it looked much like the Schmidt photo in *Burnham's Celestial Handbook*, although not so contrasty. Down at the thick end, I could glimpse all of the filamentary stuff — it was terrific!

I enjoy *Deep Sky* very much; especially the article on planetary nebulae in the spring issue. I like looking at the obscure ones and seeing how much detail is visible and how their appearance corresponds to their magnitudes. In the article, NGC 7662, a favorite of mine in Andromeda, was somewhat short-changed. I like it because you *can* see the detail inside with 300x or 400x on a good, steady night.

What about a forum for amateur observers, wherein people could contribute their thoughts about certain objects? *Deep Sky* might be ideal for this purpose, as it has a three-month lag time. In any event, congratulations on a neat magazine!

Pete Thurmes
2880 North Helen Street
North St. Paul, MN 55109

Dear Pete/ Thanks for your comments and suggestions about a reader's forum on selected deep-sky objects. Readers are always encouraged to send in reports on observing they do, and I'll keep your thought in mind as more space becomes available. — D.J.E.



Sights of Cygnus ***Clockwise, from upper right:*** **the entire constellation photographed by Tom Eby; NGC 6960, the western piece of the Veil Nebula, photographed by Evered Kreimer; the North America Nebula photographed by Rick Dilsizian; nebulosity near the Veil sketched by Alister Ling.**

Dear Dave / This summer I had a great opportunity to observe nebulosities in Cygnus, and found both Phil Harrington's article in *Deep Sky#7* and Steve Bardwell's article in the July *Astronomy* helpful. I was observing with a group of French amateurs north of Montreal, and the sky was quite clear, dark, but extremely turbulent. It was windy enough to push my 12.5-inch f/5.6 Dobsonian in azimuth! But this was the first night in the country for my recently-finished telescope, so I decided to view some favorite objects using a nebular filter.

The North America Nebula was bright and obvious, and I even came across two parallel bands of light which had to be the Pelican Nebula. Even inexperienced observers easily saw these two bands of soft light. Since the air was turbulent, I stuck to wide-field observing and continued my voyage through Cygnus. The Veil Nebula was gorgeous; both arcs were quite well-defined and detailed. While scanning between them, I noticed the section called NGC 6979 for the first time. Then the triangular middle section of the Veil crept into the field of view. It was unmistakable, and generated some unprintable comments from the old timers! I managed to rough out its position on my AAVSO charts, along with a little section south of the variable star GP Cygni, before cirrus clouds

moved in and finished the observing session 15 minutes before twilight would have.

The following night was perfectly calm, but featured a light smattering of clouds — leaving holes of dark sky here and there. Back into Cygnus I went, continuing my previous night's escapade, and I began observing more emission and reflection nebulae. First on the light was the supernova remnant NGC 6888, which was obvious and even showed faint nebulosity in the middle. The nebulosities surrounding Gamma Cygni were not as obvious as they were the previous night, but there was a clear dark lane between the nebulae. About a degree and a half west of Gamma I picked up a dark patch with a wide pair of white stars sitting on the edge — could this be a Barnard object?

I sketched the Veil Nebula region using the 12.5-incher, and enclose it for your inspection. The triangular wedge seems rather arbitrarily cut off — this is because the moon rose. The kink in the nebulosity at the upper left of the triangular section (A) was quite pronounced, whereas most of the nebulosity had diffuse edges. The thin spike lay right next to a wide double star. The nebulosity marked (B) was a diffuse blob without much detail, and roughly hexagonally shaped. The (C) section was moderately bright — about the same as B — and enclosed a star. Nearby (E) was more difficult, appearing as a group of unresolved stars. Section (D) was fairly easy, lying south of the main arc of the Veil complex. Much more difficult is (F), which consists of three sections linked by a tenuous bridge of nebulosity.

Alister Ling
1509 Sherbrooke Street West, #101
Montreal, Quebec Canada H3G 1M1

But what about comets? These are not really "deep-sky" objects, but they *look* like deep-sky objects. What about some photos of them in the next issue?

I am an active member of the Societe d'Astronomie Populaire of Toulouse, France, whose members include about one thousand amateur and professional astronomers. I also participate in the bimonthly magazine, *Pulsar*. I enclose a copy for your inspection.

Herve Le Tallec
15 Rue Perchepinte
F-31000 Toulouse FRANCE

Dear M. Le Tallec / Thank you for your suggestion: I once ran an article on observing comets, in fact as the lead article of the very first issue of Deep Sky Monthly *(in June 1977) and was soundly scolded for blending comets with deep-sky objects. There will have to be overwhelming reader demand to warrant breaking the "solar system rule" again!*

For readers of French, Pulsar *is a slick and information-packed journal whilch includes many finder maps, photos, and other data. It is available with membership in the society, which costs 158 F (about $20, depending on the franc's rate of exchange). Write to: Biblioteque, Societe d'Astronomie Populaire, 9, Rue Ozenne, F-31000 Toulouse, France. — D.J.E.*

NGC 4319 and Mark 205

Dear Mr. Eicher / Congratulations on the last issue of *Deep Sky* (#6). I didn't know there were so many planetary nebulae in our old sky! Be sure I'm going to look at some of them with my new 16-inch telescope. In building it I've kept in mind what Richard Berry says — it's stability that counts!

Last week I observed NGC 4319 and Markarian 205 in Draco. One is a galaxy, the other a quasar: they are supposedly connected by a bridge of luminous gas, even though their redshifts indicate that they lie at respective distances of 24 and 280 megaparsecs. It's quite interesting to see such a controversial object in a backyard telescope!

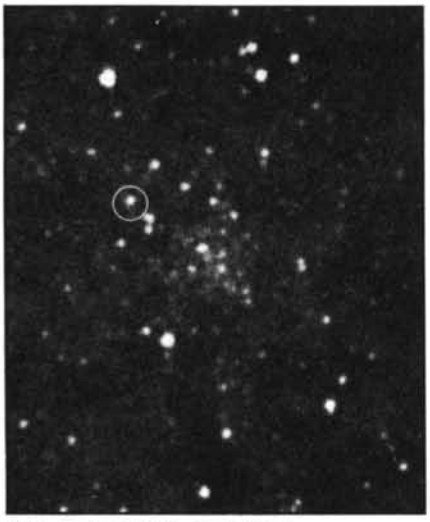
Jean-Baptiste Cretaux
6, Rue Grand
27430 St. Pierre
dn Valivray FRANCE

Dear Mr. Cretaux / Thank you for letting me know about your observation of the galaxy/quasar "pair" NGC 4319 and Markarian 205. Jack Sulentic of the University of Alabama and Halton Arp of Mount Wilson have advocated the idea that this pairing of objects may be physically associated, which would throw a kink into the reliability of redshifts as distance indicators. Just last week, however, I received a preprint from Gerald Cecil and Alan Stockton, astronomers at the University of Hawaii, who believe that the alleged bridge of material between the objects is real, but it is part of the quasar and lies at the greater distance of 280 Mpc — in other words, the two are physically unrelated. This paper will appear in the Astrophysical Journal *in the near future and should add new light to this controversy. — D.J.E.*

Halton C. Arp

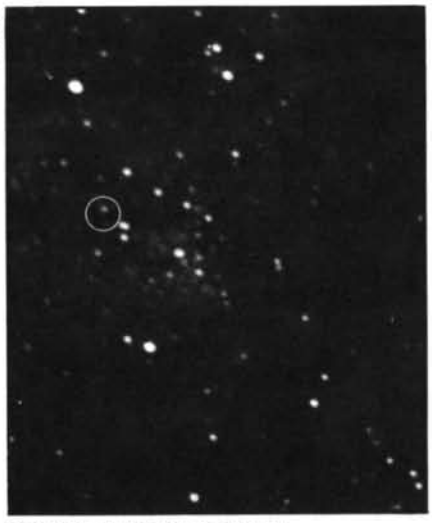
NGC 4319 and Markarian 205 photographed with the 5-meter Hale telescope.

Frank J. Melillo



M71 and variable Z Sagittae

Melillo



The faded star a year later

Spotting Cluster Variables

Dear Dave / I enjoyed reading Jim Meketa's article about Type II Cepheid variable stars (W Virginis stars) in the globular cluster M5, in *Deep Sky* #7. I'm sure that many observers had a grand time hunting down these faint stars in the midst of so many points of light!

I recently photographed a collection of globular clusters, and in the process made two exposures of the cluster M71 in Sagitta. The first photo was a 20-minute exposure on 103a-F film, made with an 8-inch f/10 SCT. About a year later I recorded M71 with the same setup but used hypersensitized TP 2415 for my 20-minute exposure. Naturally, I compared the two photos: a close look showed that a star seemed brighter on the earlier print. Sure enough, when I checked *Burnham's Celestial Handbook*, I read that the irregular variable Z Sagittae — a probable cluster member — lies at the right spot and varies between magnitudes 13.5 and 14.9. It is a reddish M-type giant, one of six in the cluster.

I would like to see more articles about variable stars in globular clusters, and will be out there observing and photographing them as much as possible.

Frank J. Melillo
119 Cedar Street
Valley Stream, NY 11580

Viewing the Faint Ones

Dear Sir / I just received *Deep Sky* 6 and must take issue with the statement, found in the low surface brightness object article, claiming that "Experienced observers know that it takes at least a 12-inch or 14-inch RFT to even consider looking at the California Nebula." I've seen it a number of times with my 8-inch at 32x from Pine Mountain Observatory in central Oregon. The nebula's long border on the opposite side of XI (ξ) Persei is well defined in the eyepiece. I agree with you that the observing site, which is very good in central Oregon, is equally as important as the telescope.

Also important is the observer's experience. And people vary from individual to individual. One observer may find the central star in the Ring Nebula easy, and the Horsehead Nebula impossible — the next may find just the opposite!

Mel Bartels
5064 E Street
Springfield, OR 97478

Back Issues of *DEEP SKY MONTHLY*

Before there was DEEP SKY magazine, there was *Deep Sky Monthly*!

Before AstroMedia Corp. — publishers of ASTRONOMY — began publishing DEEP SKY, it existed as a 20-page monthly magazine for deep-sky observers, published by amateur astronomer Dave Eicher in Oxford, Ohio. *DSM* started out as a mimeographed newsleter in June 1977, and by March 1980 became a glossy magazine, complete with observing tips, maps, charts, astrophotos, and articles for observers and photographers in tune with the current state of deep-sky astronomy. The magazine ceased publication with the May 1982 issue, after five years — 60 issues — of production. Now you can buy back issues of *Deep Sky Monthly*, while they last, in a "publisher's closeout" of the *DSM* inventory. The main article in each issue is listed below: other features, illustrations, and articles also appear in each issue. To order, send $2 for each back issue you mark on the form (or on a copy of the form), and be sure to list second choices if some issues sell out before you get your copy.

- ☐ #26/Jul '79: E.E. Barnard and the Realization of Dark Nebulae
- ☐ #27/Aug '79: The Crab Nebula — I
- ☐ #28/Sept '79: The Crab Nebula — II
- ☐ #29/Oct '79: The 1979 Supernova in M100
- ☐ #30/Nov '79: National Deep Sky Observers Gather
- ☐ #32/Jan '80: Photographic Polar Alignment
- ☐ #33/Feb '80: Observing Double Stars
- ☐ #34/Mar '80: Photographic Equipment
- ☐ #35/Apr '80: Piggybacking your Camera
- ☐ #36/May '80: Schmidt Cameras
- ☐ #37/Jun '80: Observing Globular Clusters
- ☐ #38/Jul '80: Photography through the Telescope
- ☐ #41/Oct '80: Bright Emission Nebulae
- ☐ #42/Nov '80: Cold Cameras
- ☐ #43/Dec '80: Hypersensitizing Film
- ☐ #44/Jan '81: Photography — Messing it Up!
- ☐ #45/Feb '81: More on Film Hypersensitization
- ☐ #46/Mar '81: Exploring Winter Nebulae
- ☐ #47/Apr '81: Observing Detail in Galaxies
- ☐ #48/May '81: Choosing a Film for Photography
- ☐ #50/Jul '81: The Scutum Starcloud
- ☐ #51/Aug '81: The Astrophoto IV Conference
- ☐ #52/Sept '81: Using Technical Pan 2415
- ☐ #53/Oct '81: Riverside 1981
- ☐ #54/Nov '81: $4 Astrophotography
- ☐ #55/Dec '81: Schmidt Camera Photography
- ☐ #56/Jan '82: Constellation Mopping
- ☐ #57/Feb '82: Astrophotography with a Common Scope
- ☐ #58/Mar '82: The Messier Marathon
- ☐ #59/Apr '82: Observing the Virgo Cluster
- ☐ #60/May '82: Star-Test your Telescope

To order, send this coupon or a reasonable facsimile with your check to: D. Eicher, DSM Closeout Sale, 826 North Cass Street, Apt. 101, Milwaukee, WI 53202 telephone (414) 272-0155. Please make checks payable to Dave Eicher and allow four to six weeks for delivery. Deduct 10% for orders of 10 or more issues.

Name

Address

City/State/Zip

Low Surface Brightness Observing

Dear Dave / I would like to add another object to the list of low surface brightness objects in *Deep Sky #7*. Surrounding Gamma Cygni (Sadr) is a huge complex of faint emission nebulosity, collectively catalogued as IC 1318. Although this object is neglected in both *Burnham's Celestial Handbook* and the Webb Society's *Handbook*, an excellent photo of the group appears on pages 6 and 7 of your last issue.

Observing in the California Sierras last August, at 9000 feet, I saw six distinct patches of nebulosity which together overfilled the 4° field of my 80mm Lumicon superfinder at 16x. Most prominent was a glow measuring 30' x 20', elongated northeast-southwest, and located approximately 2° northwest of Gamma. Also distinct were two parellel strips of nebulosity divided by a dark lane and situated just east of Gamma. As is the case with many low surface brightness objects, the key to detecting IC 1318 was not simply large aperture, but rather clear, dark skies, and a low-power field of view.

Steve Gottlieb
155 San Carlos
El Cerrito, CA 94530

Northern Bias

Dear Dave / As a Australian observer, I often find glaring examples of southern deep-sky objects being left out of journals published in the Northern Hemisphere. When I read the article "Observing Planetary Nebulae" in *Deep Sky* 6, I noticed that the comprehensive list of such objects only went down to declination −40°. There is one remarkable planetary at −57° which readers may be interested in.

NGC 3918 is an 8th magnitude, 10″ diameter planetary in the constellation Centaurus. Easily found near Crux, it looks almost like a star in a low power field in my Celestron-8. Higher powers show it as being perfectly circular, uniform in surface brightness, and much like a "white spot in space." In larger telescopes, it apparently looks bluer. It has a high surface brightness, and is very easy to observe, but at its declination, most American observers have probably never seen it.

Many publications overlook NGC 3918, but is this because of the familiar "northern bias" or just a lack of southern observers? There are many fine southern objects waiting for attention. They may have to wait until, say, Australia puts out a magazine like *Deep Sky*. Until then, I'm quite content to read the "northern" copy!

Lex von Treifeldt
96 Jubilee Terrace
Bardon, Queensland
4065 AUSTRALIA

Inside View

My Friend in Andromeda

I remember well when I was 15 years old and became interested in watching the sky. I didn't know about where anything was, nor what it would look like, but curiosity led me to start randomly exploring with a pair of binoculars. One autumn night I came upon a fuzzy patch of light rising over the cornfield in back of my house in suburban southwestern Ohio. The object's image was indistinct, as a thin blanket of haze dominated the eastern horizon. What was this thing which looked so different from everything else? As I lay in the back yard — snuggled in a sleeping bag, munching on popcorn, my dog running in circles and barking at imaginary rabbits — stumbling across this distant, alien object was about the most exciting thing that could have happened.

The next day I went to Miami University's science library and discovered *Astronomy*, *Sky and Telescope*, and books which claimed that this mysterious patch of light was the Andromeda Galaxy, the closest spiral. This was fascinating beyond words. I took the binoculars out again that night and stared at the pale, oval image of greyish-white light. Could this light really journey 2.3 million years before it hits my retina? I knew I had to have a telescope.

As I gained experience in observing, looking at fainter and fainter objects, I always returned to M31 when it was above the horizon. It became an old friend, something that stayed constant in spite of the changes I went through growing up in Ohio. Yet as M31's image stayed the same, our vision of it has changed during just the last 8 years — as we've hypothesized galactic coronas and revised our distance and mass estimates, and also redefined what amateur astronomers can see with a backyard telescope. Now, in this issue, Lowell Observatory astronomer Brian Skiff has written the most comprehensive observing article ever published about M31.

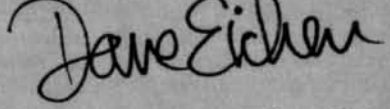
Running alongside the article is a supergraphic device which depicts, to scale, the sizes and distances between members of the M31/Milky Way system, including the major satellites. It shows that the sister spirals are actually quite close: only 13 M31s, stacked end to end, would fill the gap between them. It is no wonder that the Andromeda Galaxy measures over 3° across, and offers such a wide variety of detail for small and large telescopes operating under dark skies. On page 10 you'll discover a finder chart showing details within the galaxy — star clouds, globular clusters, and open clusters.

This issue also contains an article for astrophotographers — a guide to films and exposure times by ace photographer and professional stock analyst David Healy. A great number of films were introduced into the market during the past couple of years; this work explains what is good and what is bad about new and old films alike, and offers suggestions for successful exposure times. Not only can you observe the Andromeda Galaxy, but you can also go out and take a picture of it as well.

Our third feature deals with objects closer to home. Jim Garasich, an experienced observer and student who uses the 30-inch Thaw refractor in Pittsburgh, has detailed a constellation that will keep you busy for the entire season. Cassiopeia contains 37 — count 'em, 37 — open star clusters of all configurations, brightnesses, and stellar populations.

After looking at a few of these Milky Way clusters, switch back to hunting clusters in the spiral arms of M31. Realizing the enormous distance to M31, and the fact that those photons have journeyed through space since *Australopithecus* roamed the Earth, is a humbling thought. The Andromeda Galaxy certainly deserves its place as one of the most observed and studied objects in the sky. Indeed,when I think of M31, I'll always think of the time I lay out in the back yard with the popcorn and the barking dog and the old pair of binoculars — a time when the world seemed a whole lot simpler.

Warm regards,



Dave Eicher
Editor

ALL ABOUT M31

by Brian Skiff

It's in every astronomy book, along with Saturn, Mars, and the asteroids. Like the Moon, it is looked at and then overlooked. It is Messier 31, the majestic spiral galaxy in Andromeda, about which so much has been written, and from which we've learned so much about the behavior of the universe.

In the early pages of my observing log, I wrote: "It doesn't look like much in the telescope." I was observing from the middle of a large city, and was disappointed at not having seen spiral structure in my 2.4-inch refractor. M31 is not an easy object in which to view detail — many more clues to a galaxy's nature are visible in its face-on neighbor in Triangulum, M33, although M33 is half again as far from Earth. The reason why details in its spiral arms remain hidden is that M31 is highly inclined to our line of sight.

Yet sheer proximity has its advantages, like making the galaxy a bright naked-eye object. Staring at it in binoculars on a dark night, I've wondered what the view would be like were it not a narrow inclined oval, but a face-on, circular disk. Could we see the spiral arms in binoculars? I like to think so.

The Nature of M31

The most recent estimate of the distance to M31 is 760 kiloparsecs (nearly 2½ million light-years). The brightest stars in the galaxy are red and blue supergiants, distinguishable by their slight, irregular variability. If they are like stars of the same class in the Milky Way — such as Mu (μ) Cephei, a red supergiant, and Zeta[1] (ζ^1) Scorpii, a blue supergiant — and those in the nearby galaxies M33 and M101, they have absolute magnitudes of −8 to −9, and shine at apparent magnitude 15. With a large amateur scope, a few of the stars you see projected on M31 are actually inside the galaxy. Unfortunately no extensive study of these stars has been published, so finder charts are not yet available.

Without doubt other stellar members of M31 have appeared on amateur photographs — but only temporarily. They are novae, which appear at the rate of about two dozen per year. In 1956 the Mount Wilson astronomer Halton C. Arp published an early synopsis of novae in M31. Arp photographed the big spiral on 290 nights over a period of a year and a half, discovering 30 novae. The brightest of these shone at magnitude 15 or 16, corresponding to absolute magnitude −8.5 — close to that of bright novae in the Milky Way. Since the 1950s, the Russian astronomer A. Sharov and the Italian astronomer L. Rosino have followed novae in M31. Arp, Sharov, and Rosino all found the majority of novae within 15 arcminutes of M31's core, just as Milky Way novae are concentrated toward the galactic center in Scorpius and Sagittarius. Arp's paper, by the way, provides the only photoelectric measures of stars in the main body of M31, many of which are indicated on the photograph on page 10 and in the accompanying table.

As viewed from Earth, M31 is tilted only 12.5° from edge-on, making its spiral structure difficult to discern. But even at the turn of the century, before the galaxy's great distance was established, M31 was regarded as a "spiral nebula." Recently Paul Hodge of the University of Washington has found that the distribution of dust lanes and open clusters over the galaxy most strongly suggests a common two-arm spiral pattern wound about the nucleus several times. This outline is probably distorted to some extent by Messier 32, the compact elliptical companion galaxy apparently at the periphery of M31.

The dust lanes along the northwestern flank clearly show that this side is closer to us. The arms are spinning toward us on the northeastern end and away from us on the southwestern end. A 1970 radial velocity study by Vera Rubin and Kent Ford showed that HII regions extend out 2° from the galaxy's center, while radio 21-centimeter measures done by Morton Roberts and Robert Whitehurst, show that HI (neutral hydrogen) extends out to 2.5°. These data show that the rotation speed in the outer parts of the galaxy is constant, at around 230 km /sec — a common but not

Essential Facts

NGC 224 = Messier 31
- Right Ascension: 00h42m44.6s
- Declination: +41°16.1′ (2000)
- Type: SA(s)b
- Dimensions: 177.8′ x 63.1′ (at B magnitude 25 per square arcsecond isophotes)
- V = 3.45 B-V = 0.91
- Mean Surface Brightness: 13.4 (magnitude per square arcminute)
- Inclination to line of sight: 77.5°

NGC 205
- Right Ascension: 00h40m21.7s
- Declination: +41°41.3′ (2000)
- Type: E5 pec
- Dimensions: 17.4′ x 9.8′
- V = 8.0 B-V = 0.84
- Mean Surface Brightness: 13.6

NGC 221 = Messier 32
- Right Ascension: 00h42m42.0s
- Declination: +40°51.9′ (2000)
- Type: cE2
- Dimensions: 7.6′ x 5.8′
- V = 8.2 B-V =0.94
- Mean Surface Brightness: 12.3

sources: RC2, and de Vaucouleurs and Leach, 1981.

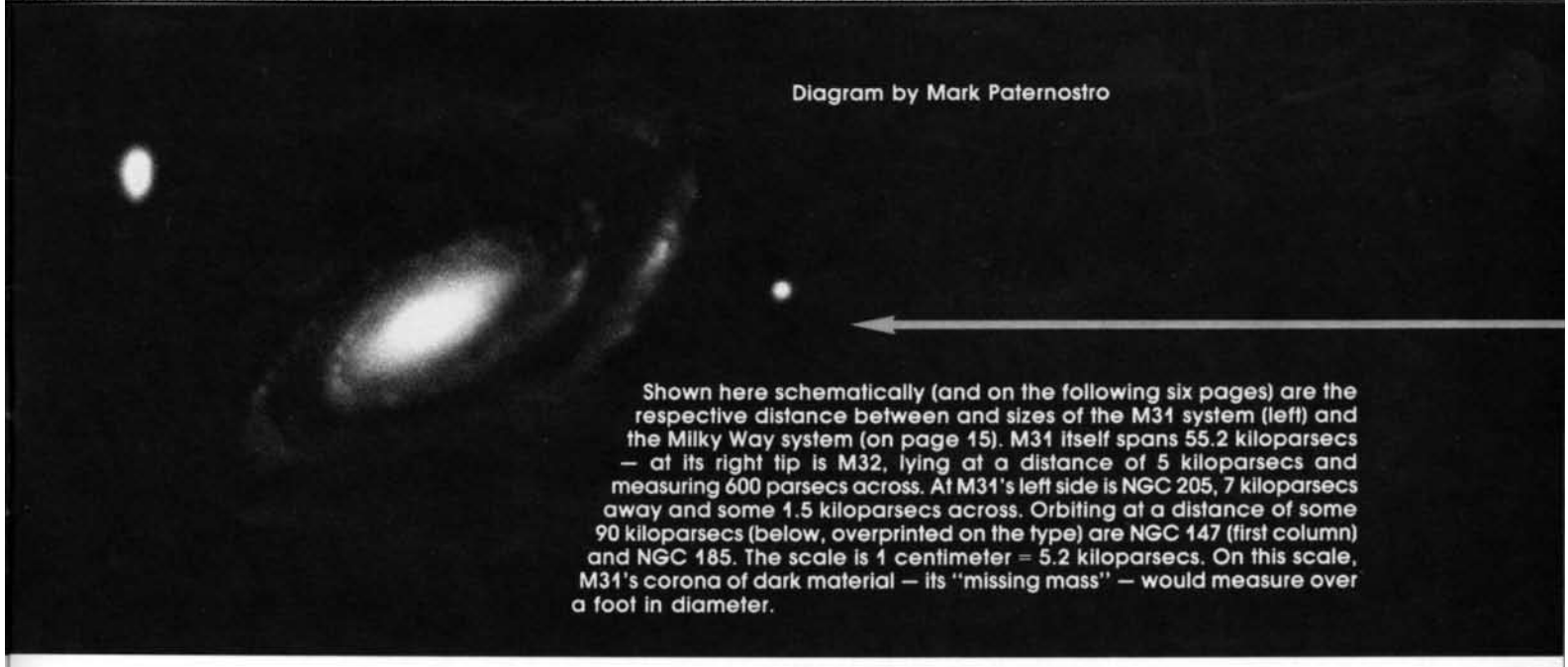


Diagram by Mark Paternostro

Shown here schematically (and on the following six pages) are the respective distance between and sizes of the M31 system (left) and the Milky Way system (on page 15). M31 itself spans 55.2 kiloparsecs — at its right tip is M32, lying at a distance of 5 kiloparsecs and measuring 600 parsecs across. At M31's left side is NGC 205, 7 kiloparsecs away and some 1.5 kiloparsecs across. Orbiting at a distance of some 90 kiloparsecs (below, overprinted on the type) are NGC 147 (first column) and NGC 185. The scale is 1 centimeter = 5.2 kiloparsecs. On this scale, M31's corona of dark material — its "missing mass" — would measure over a foot in diameter.

universal feature of rotation curves of other spiral galaxies including our own. For such systems to remain stable there must be great amounts of mass beyond where the luminous spiral arms end. At present we have nothing but this dynamical evidence to show that the matter exists — whatever it is, it just doesn't put out enough light for us to observe. The data imply, however, that as much as 90 percent of the masses of the Andromeda Galaxy and Milky Way are outside the traditional visible part of the objects.

The spiral arms in M31 are dominated by star clouds, or stellar associations — young, loosely bound collections of stars having a common origin. Nearly 200 of these regions, catalogued by the Canadian astronomer Sidney van den Bergh, are mapped in Hodge's *Atlas of the Andromeda Galaxy*. A number of the well-defined associations are marked on the photographic finder map on page 10; most have bright open clusters embedded in them.

The brightest and richest association is conspicuous enough to have its own NGC number. NGC 206, A78 on the map, is about 50′ southwest of the center of the galaxy. Van den Bergh made a photometric study of this star cloud and compared its characteristics to associations in our Galaxy. The brightest member stars are 17th magnitude objects, and more than 300 are brighter than about magnitude 21. Integrating the brightness of all stars above this limit, van den Bergh found a total V magnitude of 13.0 for the entire cloud. More recently, Hodge got a value more than a magnitude brighter. At the telescope, you might try to estimate the brightness of NGC 206 yourself. Use moderate or high powers to isolate it from the luminous background of the main galaxy.

NGC 206 does not seem to have any glowing H II regions within it — no "Orion Nebulae". But scattered all across the galaxy are many such objects. The French astronomer C. Courtes and his collaborators catalogued nearly one thousand emission nebulae in M31. Using an Hα filter to isolate the nebulae, their intriguing photographs give an unusual perspective of the galaxy. Curiously, none of the nebulae are as large or as bright as those in M33 and M101, which are easily viewed in a large telescope even though their parent galaxies lie much farther away. From my own observations and inspection of photographs, it seems that none of the M31 nebulae are conspicous in amateur telescopes. Even the brightest one, located on the finder map around C205 and A69, is overpowered by the light of the star cluster.

Some 400 open clusters in M31 have been catalogued, but not well studied. These are only the very brightest in the galaxy; the fainter ones tend to be too small and faint to distinguish from stars. Hodge found that M31's clusters resemble the largest young open clusters in the Milky Way, such as the Double Cluster in Perseus and NGC 6231 in Scorpius. As with young clusters in our Galaxy, the luminous objects in M31 at least crudely outline the spiral arms.

While the open clusters are not well observed, the globular cluster system in M31 has been the subject of repeated and extensive study. The most recent is by David Crampton and his collaborators. Their catalogue of globulars includes 509 objects found on slitless spectra plates taken with Mauna Kea's 3.6-meter Canada-France-Hawaii telescope. The spectral data enabled them to confirm all the objects as star clusters: similar-looking H II regions, for instance, could be distinguished by their emission lines. They were able to derive colors and diameters for most of them as well.

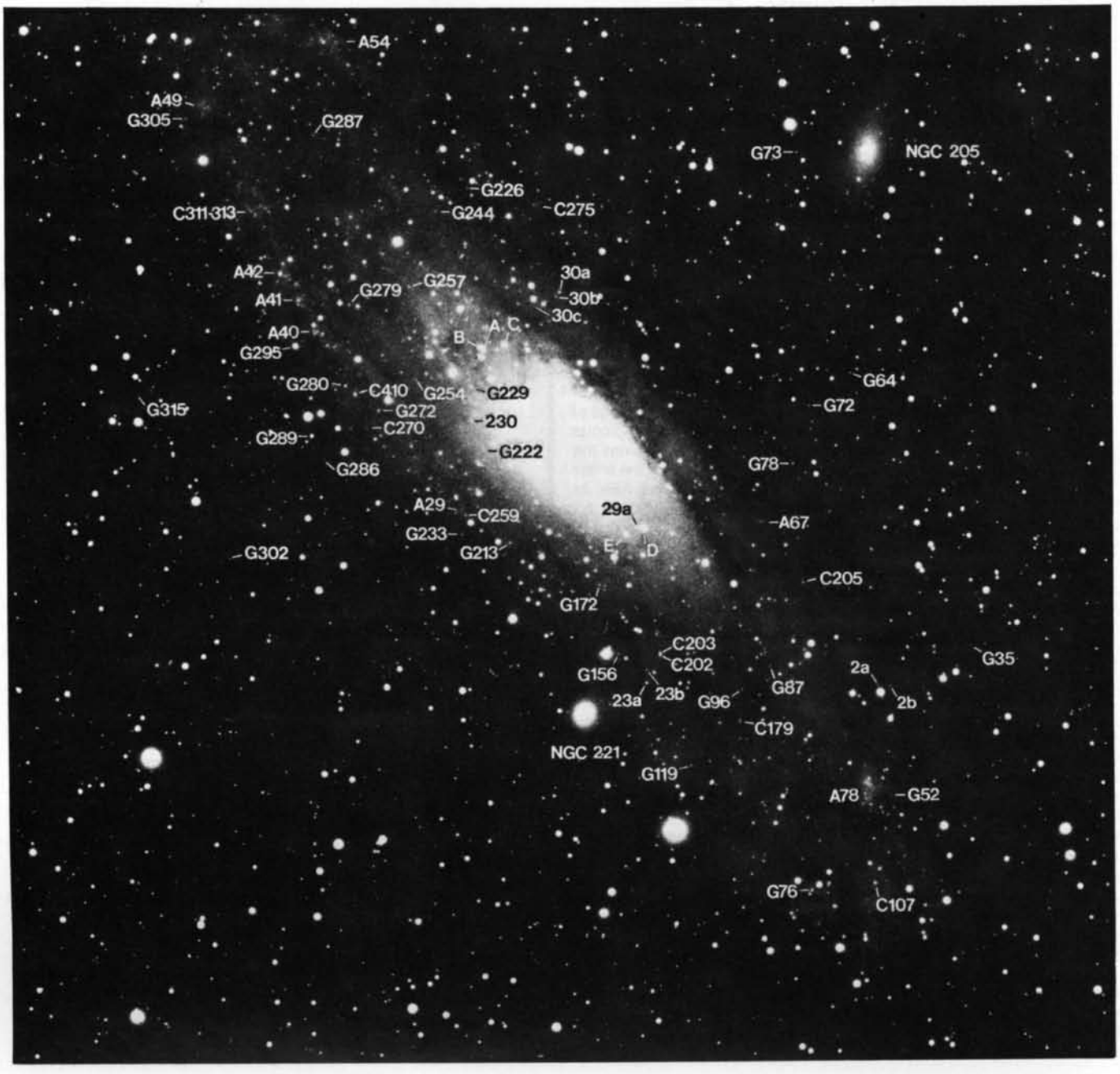
Under dark skies, 4-inch or larger telescopes reveal M31's most prominent dark lane, lying on the northern side of the nucleus. Photo by Martin C. Germano; 8-inch f/10 SCT, 60-minute exposure on 103a-F.

The M31 system of globulars resembles the Milky Way's in many respects. The clusters concentrate in a halo around the center of the galaxy, and thin out away from the center at about the same rate as we see in our Galaxy. Likewise, clusters more distant from the centers of both galaxies have larger diameters, since gravitational forces are not so strong. The distant clusters are also intrinsically fainter, but the reason for this is not obvious.

The Andromeda Galaxy has eight known companion galaxies — all intrinsically faint ellipticals. The two brightest are familiar: Messier 32 and NGC 205 (infrequently labeled as Messier 110). M32 is a "compact elliptical," that is, its central surface brightness is very high despite being a small object, where a low central density would normally be expected. It is probably projected slightly in the foreground of M31, but is close enough to M31 — perhaps 5 kiloparsecs away — that both galaxies are distorted as a result. The photo of M32 in Arp's *Atlas of Peculiar Galaxies* shows a faint streamer extending from the main body of the galaxy.

NGC 205 has been well-studied. Its dark patches and anamalous association of blue stars near the center have been known about since Walter Baade's explorations of the system several decades ago. Detailed surface photometry shows that the outer regions of this galaxy are also distorted in the direction of M31. (It probably lies 7 kiloparsecs from M31.) A color-magnitude diagram of its individual stars was recently published which

Below: A photographic finder chart for stellar associations, globular clusters, open clusters, and stars in M31 and in its field. North is up, east at right in the photo — V magnitudes, colors, dimensions, and/or notes are given for various objects in the accompanying table. Photo by Brian Skiff, who used the 13-inch astrographic "Pluto" camera at Lowell Observatory's Anderson Mesa Station. The exposure lasted 30 minutes on 103a-O emulsion. Right: With a 10-inch f/5 Newtonian, Lee C. Coombs made two identical 15-minute exposures on 103a-O to make this composite of M31.



Associations

A 29 — contains a prominent HII region
A 40 — compact
A 41 — compact
A 42 —
A 49 —
A 54 — rich star cloud
A 67 — contains two emission knots corresponding to C223-224
A 69 — contains bright blue stars and a triangular emission region with a very bright blue central star (C205)
A78 — NGC 206, richest star cloud in the galaxy. The brightest stars are blue main sequence stars at V~17.4. The integrated magnitude is B=11.9, derived from the sum of isophotal contours.
A102 — large; many subclusters

Globular Clusters

Name	V	B-V	diam. (FWQM)	conc.
G 35	15.6	0.89	2.9"	m
G 52	15.7	1.00	2.3	c
G 64	15.1	0.78	2.3	c
G 72	15.0	0.96	2.2	m
G 73*	15.0	0.83	—	m
G 76	14.3	0.84	3.6	m
G 78	14.3	1.13	3.2	m
G 87	15.6	0.84	2.9	m
G 96	15.5	0.90	2.7	m
G119	15.0	0.82	2.7	c
G156	15.6	0.90	2.5	m
G172	15.2	0.89	2.4	c
G205	14.8	1.27	2.9	m
G213	14.7	0.90	2.5	c
G222	15.2	0.98	3.2	m
G226	15.5	0.98	3.8	m
G229	15.0	0.79	3.4	m
G230	15.2	0.84	2.9	m
G233	15.4	0.96	2.6	m
G244	15.4	1.00	2.6	m
G254	15.7	0.96	—	m
G257	15.1	0.87	3.2	m
G272	14.8	0.86	3.4	m
G279	15.4	0.74	4.9	d
G280	14.2	0.95	2.7	m
G286	15.7	0.78	2.5	m
G287	15.8	0.84	2.2	c
G302	15.2	0.78	2.5	m
G305	15.6	0.98	2.2	m
G315	15.7	0.85	—	m

*G73 is associated with NGC 205.

Open Clusters

C179 — involved in A22
C202 — involved in A24
C203 — involved in A24
C205 — involved in A69
C223 — involved in A67
C224 — involved in A67
C259 — involved in A29
C270 — involved in A32
C275 — involved in A59
C311 —
C312 — involved in A48
C313 —
C410 — involved in A33

Stars

Name	V	B-V
A	13.0	0.64
B	12.1	0.92
C	12.0	0.56
D	12.2	0.26
E	12.7	0.72
2a	15.4	0.92
2b	15.4	0.80
23a	14.4	0.43
23b	15.3	0.75
29a	14.7	0.55
30a	14.2	0.55
30b	14.8	1.28
30c	16.5	0.99

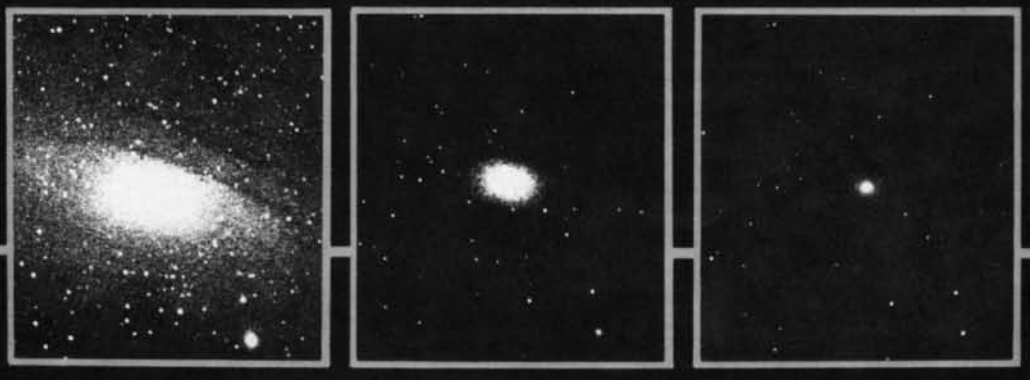
showed a distance indistinguishable from that of M31, and the characteristics of the stars and that its stars are similar to stars in Milky Way globulars. The resemblance to old globular clusters indicates that most star formation in NGC 205 occurred in the ancient past. But several dark clouds and a patch of young blue stars near the center show that star formation is probably going on right now, though at a very low rate. In this respect NGC 205 resembles NGC 185, one of two other companion galaxies about 7° north of M31. It and NGC 147 are somewhat fainter objects, having fewer stars and less mass.

Four more dwarf elliptical galaxies were found by van den Bergh during a special photographic survey using Schmidt plates. These objects, designated Andromeda I, II, III, IV, were resolved on photographs taken with the Palomar 5-meter telescope. They are approximately at the distance of M31, but because of their exceedingly low surface brightness, they are invisible in amateur instruments.

Observing Andromeda's Great Spiral

Messier 31 is an easy naked eye object, visible even on hazy nights, in full moonlight, or from slightly light-polluted skies. In relatively poor conditions, though, you can make out only a roughly circular spot. Under dark skies, its elongation is striking in contrast to the starry foreground. From outside Flagstaff, I can see a faint star — about magnitude 6.9 — near the southwestern tip. Under the best conditions the galaxy extends past this star, which implies an observed length of about 3½°.

A 2.4-inch refractor at low power (25x, say) shows the halo more than 2° long in position angle 40°, but the outer regions fade very



Above: Jamey Jenkins used a 4¼-inch reflector and 103a-O film to make this sequence of four frames of progressively less exposure time. The first is a 5-minute exposure, showing an overexposed nuclear region and two dust lanes. The second and third frames — 2-minute and 1-minute exposures — still offer an overexposed nucleus. But the fourth frame, for which the camera opened just a few seconds, shows M31's starlike nucleus. *Far right*: A closeup of M31's center, showing perhaps the few inner kiloparsecs of the core, by Richard Berry.

slowly and really have no definite edge. The galaxy contains some weak, broad condensation, but the core appears smooth and well concentrated. As you scan toward brighter and brighter areas in the center, the core grows progressively more eccentric in relation to the halo — the northwest side of the core fades more abruptly than the southeast side, placing the nucleus off-center to the northwest. Some stars appear superimposed on the galaxy, including a 12th magnitude one on the south-southwestern side of the core.

Further details become visible in larger aperture scopes. With a 6-incher, the halo measures about 120′ x 20′ with a pronounced core 10′ across. The dark lane northwest of center can be seen without difficulty, showing some faint haze beyond it. In a 10-incher the halo extends to about 40′ wide. The core measures 7′ in width, cut off by dark lanes on the minor axis, but its length is indefinite since it fades evenly along the major axis. The inner 2.5′ of the core is quite circular and appears "opaque" like other unresolved objects of high surface brightness, such as the centers of Messier 87 and Messier 49 in Virgo. The brightness rises evenly to a central tip about 10″ across.

The prominent dark lane on the northwest side is a sharply defined strip about 1′ wide as it passses only 5′ from the core, but is clearly visible as it extends southwest past two stars aligned northeast-southwest about 15′ from the center. Two more indistinct dark lanes are discernable, one further northwest and one along the southeastern flank. On the western side of two bright stars lying about 15′ northeast of the center a spike of dark material intrudes toward the nucleus. In larger apertures, the bright nucleus has a nearly stellar center, but there also appear to be some odd brightenings with radii of about 15″.

In October 1982, I surveyed M31 with a 10-inch Ritchey-Chretien telescope, looking particularly for globular clusters and stellar associations. At 200x the limiting V magnitude was 15.3 — I determined this afterward when I found that a "threshold" star mentioned in my notes has been measured photoelectrically by Arp (this is star 23b in the Table). Nearly all the accessible objects lay along the outer rim of the galaxy, and not in the inner halo or core.

A good place to start detailed observing of M31 is with the bright star cloud NGC 206 (A78 in the finder map), embedded in the southwestern arms. In the 10-inch Ritchey at 150x it was conspicuous as a 2′ x 1′ haze elongated north-south with a sharply defined eastern flank. A few faint mottlings, probably mostly foreground Milky Way stars, scatter over the surface. Along the major axis of the region the light merges smoothly into the general haze of the galaxy's spiral arms. The globular G76, one of the brightest in the galaxy, lies not far to the southeast, close by an oblique triangle of stars. The cluster is just separable from a star of similar magnitude immediately southeast of it.

Heading northeast toward M32, the open clusters C202 and C203 — separated by 16″ — are visible and seem nonstellar at high power when compared to faint stars about 2′ southeast. Midway along the southeastern rim is C410, just visible as a starlike spot. G229, set against the outer reaches of the core, is difficult to distinguish, but is just visible at 150x. Moving northeast, A40 is barely visible as a faint haziness associated with a small triangle of unequally bright

The Andromeda Satellites

M32

is easily visible in the same low-power eyepiece field as M31. It appears as a small round patch of bright light, and doesn't change its appearance much no matter what telescope you use on it. Photo by Martin C. Germano.

NGC 205

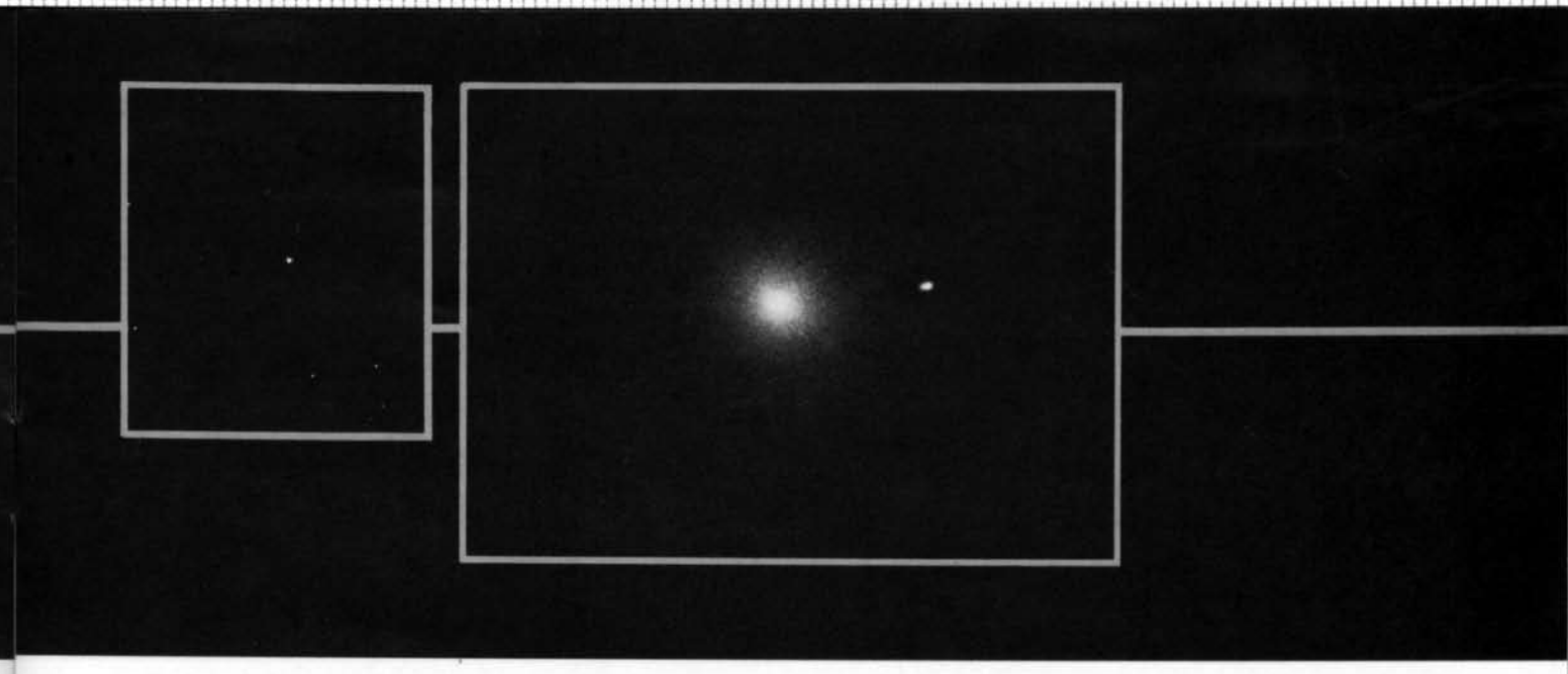
is the other satellite galaxy nearby M31. It appears as a faint, oval smudge of light without the strong central condensation of M32. It too lies in the same low-power field, though farther north. Photo by Lee C. Coombs.

NGC 147

is way up in Cassiopeia, some 7° north of M31 itself. It is one of the least massive galaxies known, and not surprisingly is difficult to spot. But a 12-inch scope should show it as an even patch of light. Palomar Observatory photograph.

NGC 185

also lies in Cassiopeia, and is slightly smaller and denser than its neighbor NGC 147. On dark nights it is just visible in a 12-inch scope — but it is certainly not easy. Palomar Observatory photograph.



The Andromeda Galaxy photographed with a backyard Schmidt camera, showing the full extent of the visible disk and the two nearest satellite galaxies, M32 and NGC 205. The knot in M31's spiral arm, at upper right, is the giant starcloud NGC 206. Photo by Ron Potter; 8-inch f/1.5 Schmidt, 4-minute exposure on hypersensitized TP 2415.

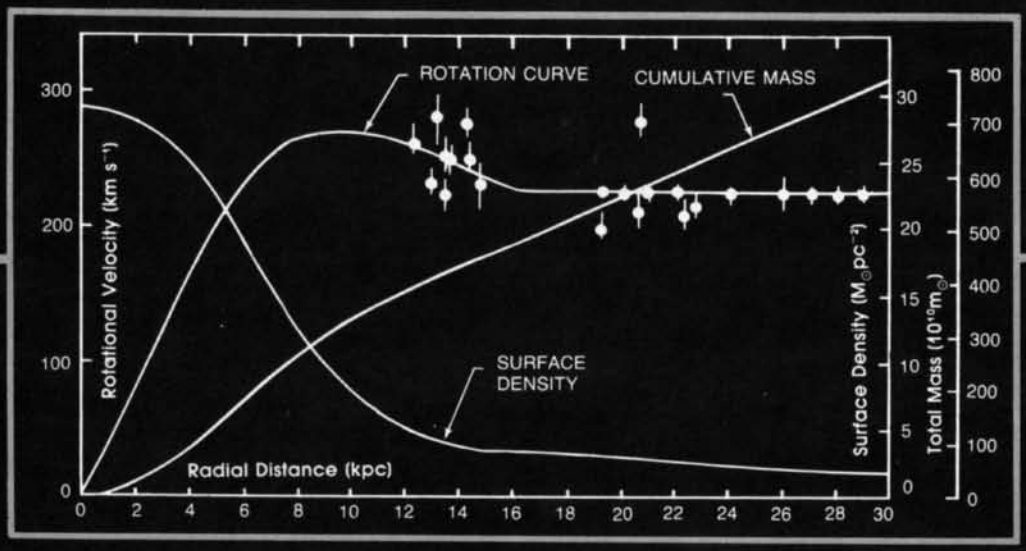
stars (I saw the southwestern member only with averted vision). Just visible 5′north-northeast is A42.

An intriguing feature marked on the *Atlas of the Andromeda Galaxy* is the string of open clusters C311-C312-C313. Disappointingly, they were not visible in my telescope. When the bright stars northeast and nearby southeast of the clusters were centered in a 30′ field, I noticed that the brightness gradient from the galaxy's disk to the sky was very strong, perhaps more conspicuous here than anywhere else.

Far out in the northeastern extremity, A102 is discernable as a faint stellar spot of about 14th magnitude, with some faint haze around it. This feature is visible probably only because the background has faded out completely.

Turning southwest along the obscured flank, few distinct objects are visible. Out of the way of most of the dark matter is A54, a broad mottled area I viewed best at medium power (about 100x) in the 10-inch scope. But the small association A67 was visible only at 200x, as was the cluster G78.

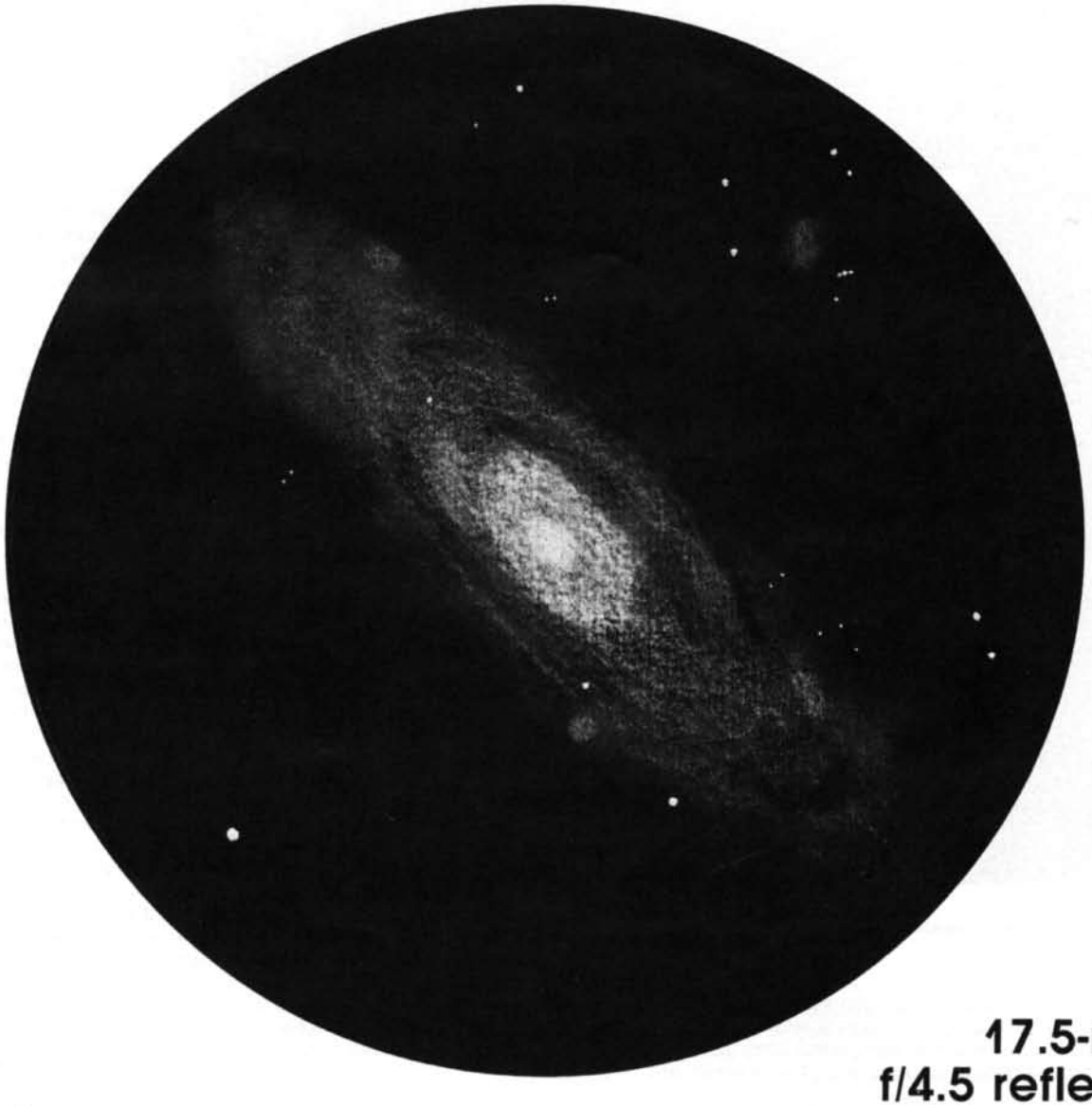
Messier 32 is the most obvious companion to the Andromeda Galaxy. A 2.4-inch telescope easily shows it at the edge of M31's halo, 24′ due south of the nucleus. It appears tiny next to its parent. The edges are irregular, and it brightens suddenly to a sharp stellar nucleus. In a 6-incher it is about 3′x2′, elongated southeast-northwest with a stellar nucleus. The intense core has the character of a planetary nebula. Viewed in a 10-inch instrument, the halo elongates toward the nucleus of M31. The brightness rises smoothly in the outer parts, then suddenly to a nearly stellar nucleus, but there is no distinct core. Using a 12-inch Cassegrain



This graph shows the relationship between M31's cumulative mass, its surface density, and its rotation curve. Moving outward from the nucleus, surface density drops quickly, while cumulative mass slowly rises. The rotation curve peaks at a radius of about 8 kilo-

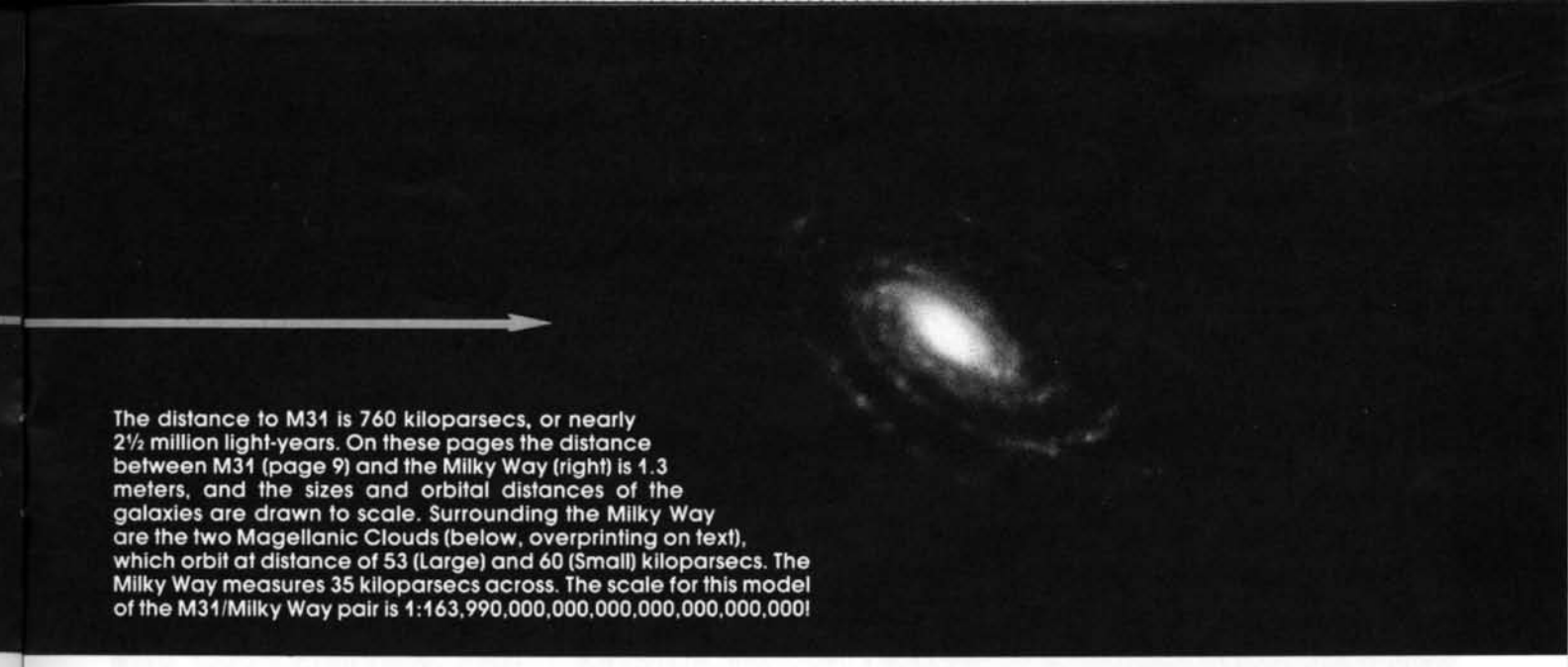
parsecs, and levels off: this indicates huge amounts of dark matter lying far beyond the visible disk of the galaxy. After E.S. Light, R.E. Danielson, and M. Schwarzschild, Princeton University Observatory.

M31 Through the Eyepiece



17.5-inch f/4.5 reflector at various powers

Composite sketch by Dave Eicher



The distance to M31 is 760 kiloparsecs, or nearly 2½ million light-years. On these pages the distance between M31 (page 9) and the Milky Way (right) is 1.3 meters, and the sizes and orbital distances of the galaxies are drawn to scale. Surrounding the Milky Way are the two Magellanic Clouds (below, overprinting on text), which orbit at distance of 53 (Large) and 60 (Small) kiloparsecs. The Milky Way measures 35 kiloparsecs across. The scale for this model of the M31/Milky Way pair is 1:163,990,000,000,000,000,000,000,000!

telescope, my friend Chris Luginbuhl finds the core elongated in pa 160°, about 1.75′ x 1′ in extent. The faint halo merges with that of M31, so the total size is difficult to estimate. The nucleus is less than 10″ across, but clearly nonstellar. A faint star is visible 2′ east of the center.

This second companion lies 37′ northeast of the center of M31. Its comparatively large angular size results in a moderately low surface brightness. Still it is visible in binoculars; small instruments show the galaxy as a diffuse haze elongated southeast-northwest and weakly conentrated toward the center. A 2.4-inch refractor will catch two stars about 4′ and 6′ south of the center. In larger apertures it is best viewed at medium powers. With my 10-inch Ritchey it was about 9′x3′ in size, elongated in p.a. 165°. The core is 3′x2′, but no sharp nucleus is visible. A 14th magnitude star is involved in the halo toward the south-southeastern end.

The finder chart shows all the objects discussed above plus many others that should be visible in fairly large amateur instruments, based on my inspection of many photographs.

Projects in Observing M31

There are a few areas in which readers can make some really neat observations of M31. These either haven't been done at all or haven't been discussed in popular astronomical magazines for many years.

The first is redetermining the maximum visual extent of the galaxy. We've all read about being able to see it 5° long. Has anyone *tried* this lately? Such observations should be referred to specific stars in the field that can be measured later on photographs. Perhaps it would also be interesting to use different instruments from the same site to see how the observable length changes with different apertures and magnifications.

Experimenting with nebular filters, visually and photographically, may turn up some interesting results. I encourage someone to try photographing the galaxy with a narrow-band filter — an Hα or a Lumicon UHC — to capture emission nebulae. On such photographs the general light from the galaxy would be greatly suppressed, but that should make the nebulae all the more obvious. As noted in Table II, some of the associations are covered by HII regions, so these would be prime targets for such experiments. Owners of large telescopes might see if some of these nebulae pop out visually. I have tried it successfully on M33 and M101, but have not yet had the opportunity on M31.

In going through the technical literature, I noticed that reports on novae by Rosino and Sharov suddenly ended in the mid-1970s. If they are no longer monitoring the galaxy for novae, why can't amateurs take over? A big percentage of the ones that occur (one or two every month!) are brighter than 17th magnitude, within easy photographic reach of a 10-inch or 12-inch telescope. Such searches could be done by using "Problicom"-type projection blinking techniques or with a direct blink comparator. Will the next nova in M31 be discovered by backyard astronomers?

Brian Skiff is an astronomer at Lowell Observatory in Flagstaff, Arizona, where he is working on photometry of solar-type stars and discovering asteroids. He is an experienced deep-sky observer and a long time contributor to Deep Sky. *He is currently working on a book on observing, to be published by Cambridge University Press in 1985.*

An Observer's Bibliography for The Andromeda Galaxy

Arp, Halton C. 1956. Novae in the Andromeda Galaxy. *A.J.* **61**:15

Van den Bergh, Sidney. 1964. Stellar Associations in the Andromeda Nebula. *Ap. J. Suppl.* **9**:65.

van den Berg, Sidney. 1966. The Association OB78 in the Andromeda Nebula. *A.J.* **71**:219.

Courtes, C., Maucherat, A.J., Monnet, G., Pellet, A., Simien, F., Astier, N., and Viale, A. 1978. A Survey of H II Regions in M31. *Astr. & Ap. Suppl.* **31**:439.

Crampton, D., Cowley, A., Schade, D., and Chayer, P. 1984. The M31 Globular Cluster System. *Ap. J.* (in press).

Hodge, Paul W. 1979. The Open Star clusters of M31 and Its Spiral Structure. *A.J.* **84**:744.

Hodge, Paul W. 1981. *Atlas of the Andromeda Galaxy.* University of Washington Press: Seattle.

Hodge, Paul W., and Kennicutt, Robert. 1982. High-Resolution Optical Surface Photometry of M31. *A.J.* **87**:264.

Light, E.S., Danielson, R.E., Schwarzchild, M. 1974. The Nucleus of M31. *Ap. J.* **194**:257.

Mould, Jeremy, Kristian, Jerome, and Da Costa, Gary. 1984. Stellar Populations in Local Group Dwarf Elliptical Galaxies. II. NGC 205. *Ap. J.* **278**:575.

Roberts, Morton, and Whitehurst, Robert. 1975. The Rotation Curve and Geometry of M31 at Large Galactocentric Distances. *Ap. J.* **201**:327.

Rubin, Vera C., and Ford, W. Kent, Jr. 1970. Rotation of the Andromeda Nebula froma Spectroscopic Survey of Emission Regions. *Ap. J.* **159**:379.

Sharov, A.S., and Lyuty, V.M. 1983. Photoelectric Catalogue of Globular Clusters in the Andromeda Nebula and its Companions NGC 147, NGC 185, and NGC 205. *Ap. & Space Sci.* **90**:371.

de Vaucouleurs, G., and Leach, R. 1981. Revised Coordinates of the Nuclei of M31 and M33. *P.A.S.P.* **93**:190.

de Vaucouleurs, Gerard, de Vaucouleurs, Antoinette, and Corwin, Harold G. 1976. *Second Reference Catalouge of Bright Galaxies* (RC2). University of Texas Press.

Vetesnik, M. 1962. Photographic Photometry of Star Clusters in the Galaxy M31. *Bull. Astro. Inst. of Czech.* **13**:180.

Films For DEEP-SKY PHOTOGRAPHY

by David Healy

Right: **Though not exactly grainless, Technical Pan 2415 film still comes pretty close — a distinct advantage when enlarging photos of small objects such as the Crab Nebula in Taurus. Ron Potter took this photo with a C-14, using a three-hour exposure at f/11 on hypered 2415 with a Wratten #25 red filter.**

Plus-X, Tri-X, High Contrast Copy. SO-419, SO-392, Technical Pan 2415. 103a-E, 103a-F, 103a-O. Kodacolor 400, Kodak VF 1000, Ektachrome 400. Fujichrome 100, Fujichrome 400, Fujicolor, Vericolor, GAF 500, GAF 200, 3M 1000, Ektachrome P800/1600. At one time or another I've seen all these 35mm films recommended for deep-sky astrophotography, and at one time or another I've tried most of them.

The very length of this (non-exhaustive) list — as well as the unfamiliarity of some of the films and the rapidity at which the list is growing as new films are introduced — can oppress and discourage anyone just starting out in astrophotography.

In practice, however, the choices boil down to just a few. On a recent photographic expedition, for example, I used just two films: a fine-grained black & white film and a color slide film. These two can handle just about anything that any of the films on the list can. However, neither of my two films is commonly found in camera stores, and most of the time I develop them myself. So, deep-sky photography continues to be more demanding than snapshot photography — but it can be more rewarding too.

The Blunder List (Again)

Films and exposure times are the subjects in this, our fourth in a series of articles on deep-sky photography. The first, on polar alignment, appeared in *Deep Sky* #4, the second (on piggyback photography) appeared in DS #5, and the third (on through-the-telescope photography) ran in DS #6.

Throughout the series I've been using my disastrous first deep-sky photo of M31, the Andromeda Galaxy as a starting point. It was such a comprehensively messed-up photograph that a list of my technical blunders on this one poor photo makes as an outline on how *not* to take deep-sky photos: (1) the telescope was not polar-aligned, (2) the exposure was unguided, (3) the camera was out-of-focus, (4) I used the wrong film, (5) the focal ratio was too high, (6) the telescope's corrector plate dewed up, (7) the exposure time was too short, (8) the galaxy was too big to fit into the telescope's field-of-view, and (9) I was shooting color from a light-polluted area. The first three articles in this series dealt with blunders 1, 2, 3, 5, 6, and 8. This time we'll tackle mistakes 4 and 7.

Deep Sky: Unusual Conditions

Mistake #4, using the wrong film, and #7, too short an exposure time, are related because films you might use for deep-sky work vary widely, not only in their rated ISO/ASA speeds but also in how they maintain these rated speeds under the unusual conditions of deep-sky photography. Film speeds as given by their manufacturers are based on snapshot photographs — relatively well-lit scenes where exposure times are shorter than a $\frac{1}{10}$ of a second.

Under the long-exposure, dim-light conditions of deep-sky photography, most films lose effective speed, but they lose it at varying rates. The speed loss is called "reciprocity failure" because the film fails to respond to light with the ordinary reciprocal relationship that applies between exposure time and density. With color films (which are essentially three black and white films packed into one), the rates of reciprocity failure can vary between the different color layers, resulting in wildly shifting color values.

Beware of "Official" Speeds!

To try to make some sense out of the film-speed confusion, I offer the top table on page 21. It summarizes some of my own experiences with film speeds under deep-sky conditions. The first column lists the film type and the second column its rated ASA speed. The third column gives my approximation of its effective speed under typical deep-sky conditions: photographing an extended object such as a nebula or galaxy through a telescope with an effective focal ratio of f/6, where the exposure times generally range from 20 minutes to an hour or more.

The table shows that for deep-sky speed, the black and white spectroscopic films, especially 103a-E, are tops. These films, however, are fairly grainy, require freezer storage, and in practice, need to be home-developed. Technical Pan 2415 offers high contrast and extremely fine grain, but is useless as a through-the-telescope film for extended objects unless it's hypersensitized. (Films can be hypersensitized at home with one of the commercially available hypering kits, or you can buy already hypered film by mail from suppliers such as Lumicon.)

Among color films, my experience with the Ektachromes and VR 400 has been that both films are usable, but are excessively green-sensitive and tend to yield greenish sky backgrounds. Fujichrome 100 is quite red-sensitive and seems to have significant reciprocity failure in the blue-green. Consequently, red nebulae show up well and skyglow is suppressed, giving black sky backgrounds. Fujichrome 400, a color slide film, has some virtues as a deep-sky film when developed normally, but tends to reproduce photos with low contrast and a pinkish tinge. When developed as a negative using the C-41 process, however, Fujichrome 400 negatives can be copied in a slide duplicator onto Kodak 5072 negative film, a process which produces excellent, high-contrast slides of nebulae and galaxies. Duping also permits you to enlarge and correct any color shifts.

I now generally use just two films: Technical Pan 2415 and Fujichrome 400, both hypersensitized. Among the newer color films that amateur astronomers are successfully using for deep-sky work are Kodak VR 1000, 3M 1000, Fujicolor HR 1600 and Ektachrome P800/1600. At presstime, Agfa had recently introduced two 1000-speed color films, one for slides and the other for prints. But we'll have to see if these turn out to have any extraordinary advantage over hypered Fujichrome developed as a negative.

Exposure Times

How do effective speeds translate into

exposure times? The other table on page 21 gives some suggestions and starting points for experimentation. All of the times listed presume dark-sky conditions, through-the-telescope photography at f/6, and normal development. Some films can be push-processed for higher speed, but usually at the expense of greater graininess and loss of resolution. These times are suggestions only — some astrophotographers will find their suitable exposure times consistently different from these.

Try bracketing the recommended exposure times, or at least try two or three exposures for the same object. Bracketing exposure times for a faint nebula like the Horsehead is not necessary — at least on the long side. The exposure times listed for the Horsehead are very close to the sky fog limit, beyond which longer exposures yield only a brighter sky background and no more object detail.

For focal ratios different from f/6, doubling the recommended times for each f/stop higher and halving it for each f/stop lower should give decent approximations, particularly for films with limited reciprocity failure. Focal ratios in the f/6 series run as follows:

f/1.6, f/2.2, f/3.2, f/4.5,
f/6.3,
f/9, f/12.5, f/18, f/25

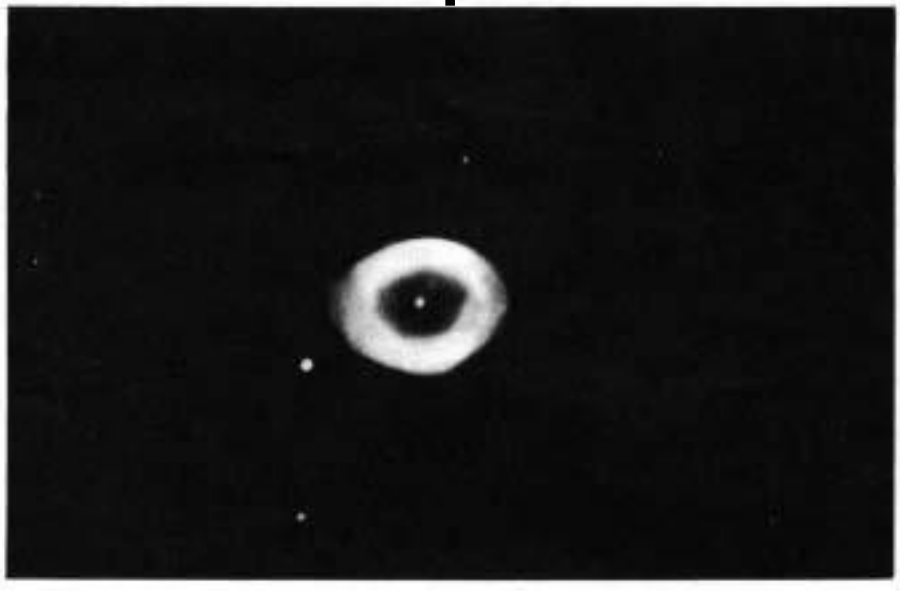
Many normal 50mm camera lenses have focal ratios of about f/1.4, as do the Celestron Schmidt cameras. Many 135mm to 200mm telephoto lenses have focal ratios in the f/3 to f/4 range. The Celestron-8 telescope is f/5 with the focal reducing telecompressor lens and f/10 without it. A typical refractor has an f/ratio around f/15.

If we ignore reciprocity failure, we see that a deep-sky photo at f/9 requires an exposure five stops, or 32 times, longer than one at f/1.6. As a practical matter, deep-sky photos at f/10 are limited to the brightest objects — M42 and M31, for example — and the fastest films. When exposures run longer than an hour, you are really testing three things only: the photographer's endurance, his bladder capacity, and the idea that astronomy is an avocation pursued for enjoyment.

Develop Them Yourself!

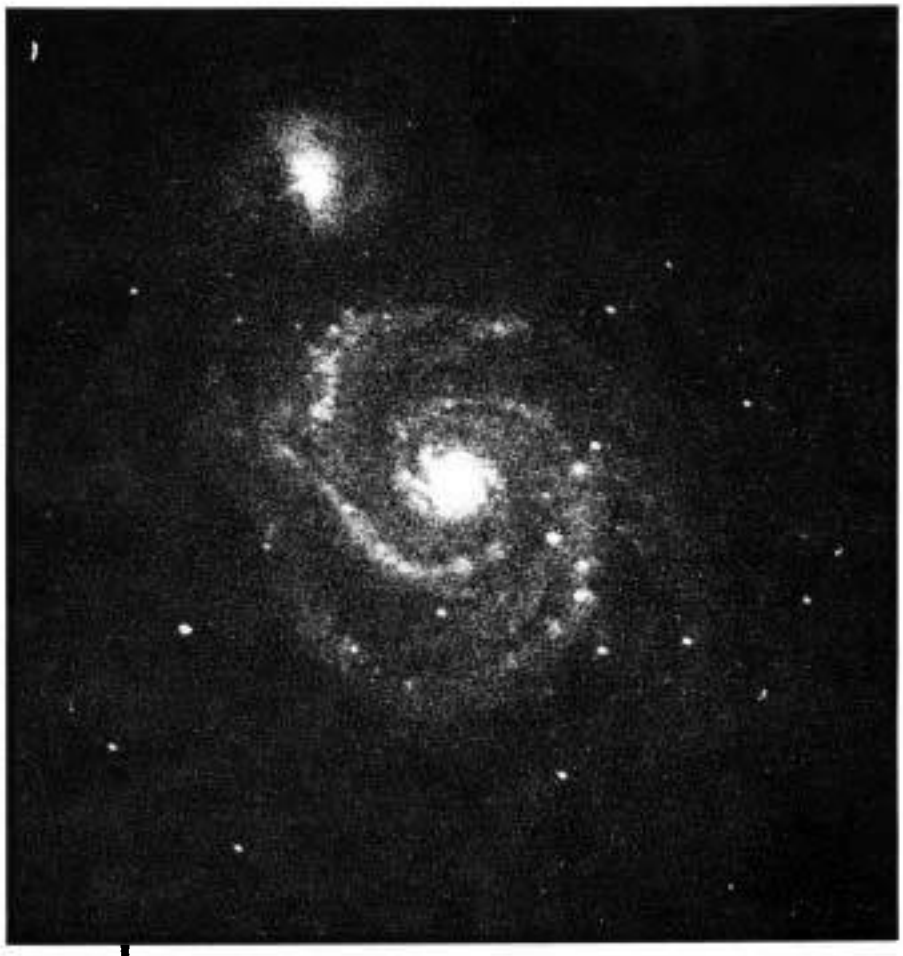
At the moment, I do all my own black and white work — developing, printing, and enlarging. Increasingly idiot-proof color processing kits have also tempted me back to developing color slides and negatives.

Being able to develop negatives promptly in the field has saved at least one of my photographic excursions.



Right: **The Ring Nebula in Lyra has a bright, reddish shell of gas (seen as a ring in profile) surrounding a 14th magnitude blue star. Alfred Lilge used a 12.5-inch scope at f/8, and a 30 minute exposure on 2415.**

Left: **M104 in Virgo is popularly known as the "Sombrero Galaxy" because of its distinctive shape. Jack Marling took this photo with a 24-inch telescope, hypered 2415, and a 30 minute exposure at f/6.5.**



The advantage of using 2415 over standard spectroscopic films is evident in these photos. M51, the Whirlpool Galaxy, is a medium-bright spiral in Canes Venatici just southwest of Benetnash — the star at the end of the Big Dipper's handle. Ron Potter's photo (*above*) was taken on 103a-E, with a C-14 in a 30 minute exposure at f/11. Though much detail in the galaxy's spiral arms has been captured, the graininess of the film is highly distracting. In comparison, Potter's other photo (*left*) displays more detail and conveys a sense of reality the other photo lacks. This was taken on hypered 2415 with a 60-minute exposure using the same telescope and f/ratio as above.

Top left: **The heart of the Pleiades, captured by Jack Gibbons with a 12.5-inch f/8 telescope and ½-hour exposure on hypered 2415. Note the wispy clouds of dust!** ***Top right:*** **M81 — a classic. Photo taken on blue-sensitive 103a-O by Lee C. Coombs, who used a 10-inch scope at f/5 and a 15 minute exposure.** ***Above:*** **The Black-Eye Galaxy, M64, in Coma Berenices has a highly-prominent dust lane that gives the galaxy its nickname. Alfred Lilge used a 12.5-inch f/8 scope, and a 1h45m exposure on 2415.** ***Left:*** **The Rosette Nebula and its open cluster, NGC 2237/9 and NGC 2244 in Monoceros, were photographed by Jack Marling with an 8-inch scope at f/4.5 for 60 minutes on hypered 2415 with a nebular filter.**

Once, developing the first couple of nights' photos with a new scope I was breaking in showed that the pictures were out-of-focus. Testing with subsequent nights' photos narrowed the problem to an old focusing screen in my camera. Substituting another focusing method solved the problem, and I was able to use the nights remaining to good effect.

The night I solved the problem, I developed the evening's focus-test photos and a picture of M51, all taken with 103a-E. When these negatives turned out well, I went back to the scope and took another picture of M51 on hypered Technical Pan. The resulting photos were ideal for comparing the two films — same subject, same equipment, same excellent night.

If you develop your own film, you can remove a few exposed frames from the camera (inside a changing bag) and develop them promptly without waiting for a whole roll to be used up — I've had all 36 shots on a roll ruined by one simple mistake not caught in time.

Developing 35mm film requires a minimum investment in equipment and no great mechanical skill. (Were it otherwise, your author — whose photographic motto is "if anything can go wrong, it will" — would not be processing his own film!) A daylight developing tank, a changing bag, a photographic thermometer, a graduate, and developing and fixing chemicals are the basic requirements for developing either black and white or color.

Hypered Film: Special Handling

Handling hypered film is somewhat more demanding. These films fog gradually over a period of days or weeks if stored at room temperatures, so freezer shortage is desirable. Hypered Technical Pan film is very forgiving, however — several lengths from a roll can be cut off and the unused portion returned to the freezer several times before the film begins to fog or lose its increased sensitivity. I've used hypered 2415 that has been freezer-stored for more than six months and it still performed well. Most color films lose their increased sensitivity more rapidly and tend to fog — these should be used promptly after hypering.

I invariably use Kodak's high-contrast developer D-19 for all my deep-sky black and white shots — it helps enhance the inherently low contrast of many deep-sky extended objects. I have found that hypered 2415 can be pushed moderately — for example, 6 minutes at 68° rather than the 4 minutes suggested by the directions — with minimal loss of resolution.

Since not every camera store carries Fujichrome or Technical Pan film, or D-19 developer, you may have to resort to mail order supplies. Many of the advertisers in the photo magazines such as *Pop* or *Modern Photography* offer mail-order film at attractive prices. If you can't convince your local dealer to order D-19 or Technical Pan, write to Kodak's Amateur Photo Information Service (1133 Avenue of the Americas, New York, NY 10036) for sources. For Fujichrome, write to Fuji Photo Ltd., 350 Fifth Ave., New York, NY 10118. Lumicon offers a good range of hypersensitized films and related astrophotographic equipment (2111 Research Drive, Livermore, CA 94550).

Printing and Enlarging

With a darkroom (however makeshift), an enlarger, and some other basic equipment like an easel and developing trays, you can make your own black and white prints. This enables you to print only the desired portions of your negatives, manipulate contrast via paper grades or filters, retouch blemishes or scratches, and improve sections of a print through dodging and burning-in techniques. In short, it puts you in control of the entire process. With a slide duplicator and Kodak 5072 film, you an copy your Fujichrome 400 negatives, producing enlarged and color-corrected slides in the process.

Home darkrooms aren't as popular as they were 10 or 20 years ago, but any astrophotographer who wants to see "professional" results should try to outfit one for himself. Commercial photofinishing is good enough for ordinary snaps, but any photo taken with a telescope deserves the best!

David Healy is Vice President of Drexel Burnham Lambert, Inc., a New York City brokerage house. He is an experienced astrophotographer, and a long time contributor to Deep Sky *magazine.*

Effective Film Speeds

Film	Rated ASA Speed	Effective Deep-Sky Speed
Spectroscopic 103a-E	600	600
Spectroscopic 103a-F	400	400
Fujichrome 100	100	100[1]
Fujichrome 100 (hypersensitized)	—	200[2]
Ektachrome 400	400	150[3]
Technical Pan 2415	160	0?
Technical Pan (hypersensitized)	—	160
Fujichrome 400	400	?
Fujichrome 400 (hypersensitized)	—	200
3M 1000	1000	150

[1]For red-sensitive layer. Blue-green speed much less.

[2]Hypering increases blue-green speed more than red speed.

[3]Exaggerated green sensitivity?

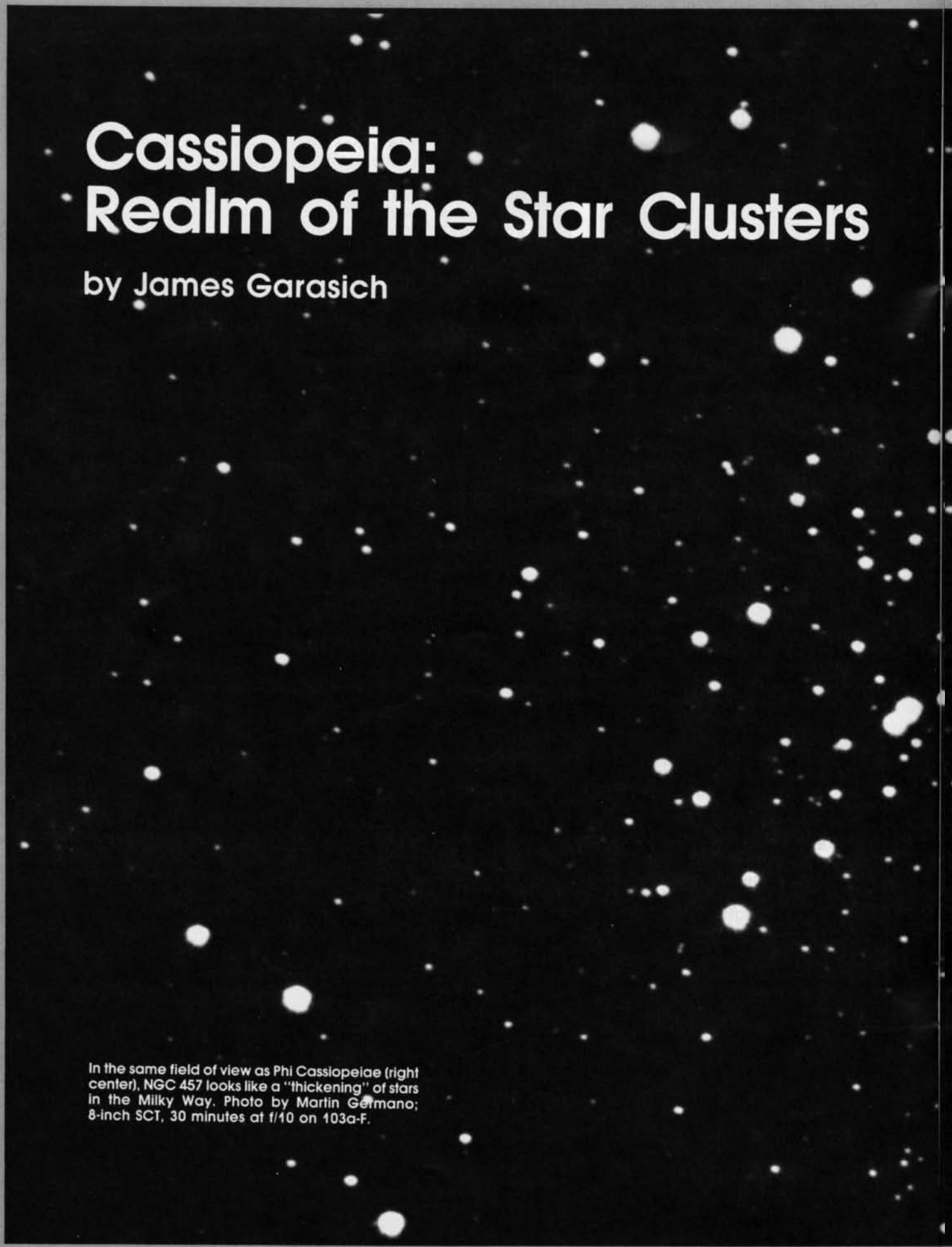
Exposure Times (Minutes), f/6 Optical System

Film	Bright Nebula (M42)	Faint Nebula (Horsehead)	Galaxy (M51)	Globular Cluster (M31)
Spectroscopic 103a-E	7	45	30	7
Spectroscopic 103a-F	10	60	45	10
Fujichrome 100	40	PDT*	PDT*	35
Fujichrome 100 (hypered)	15	90	60	15
Fujichrome 400 (hypered)	15	90	60	25
Ektachrome 400	15	?	60	15
Technical Pan 2415	45?	PDT*	PDT*	45?
Technical Pan (hypered)	15	70	60	15

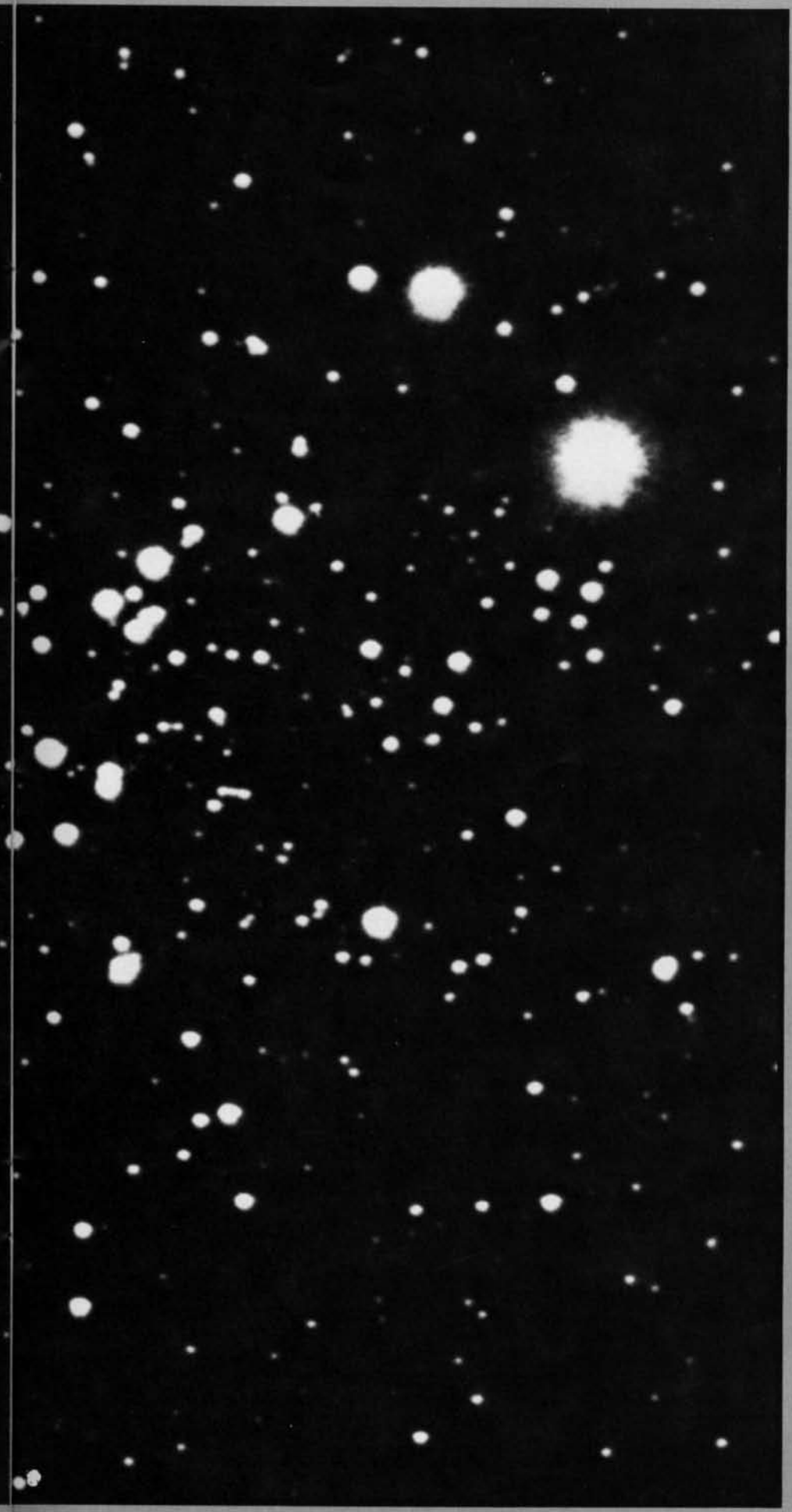
*Please don't try!

Cassiopeia: Realm of the Star Clusters

by James Garasich



In the same field of view as Phi Cassiopeiae (right center), NGC 457 looks like a "thickening" of stars in the Milky Way. Photo by Martin Germano; 8-inch SCT, 30 minutes at f/10 on 103a-F.

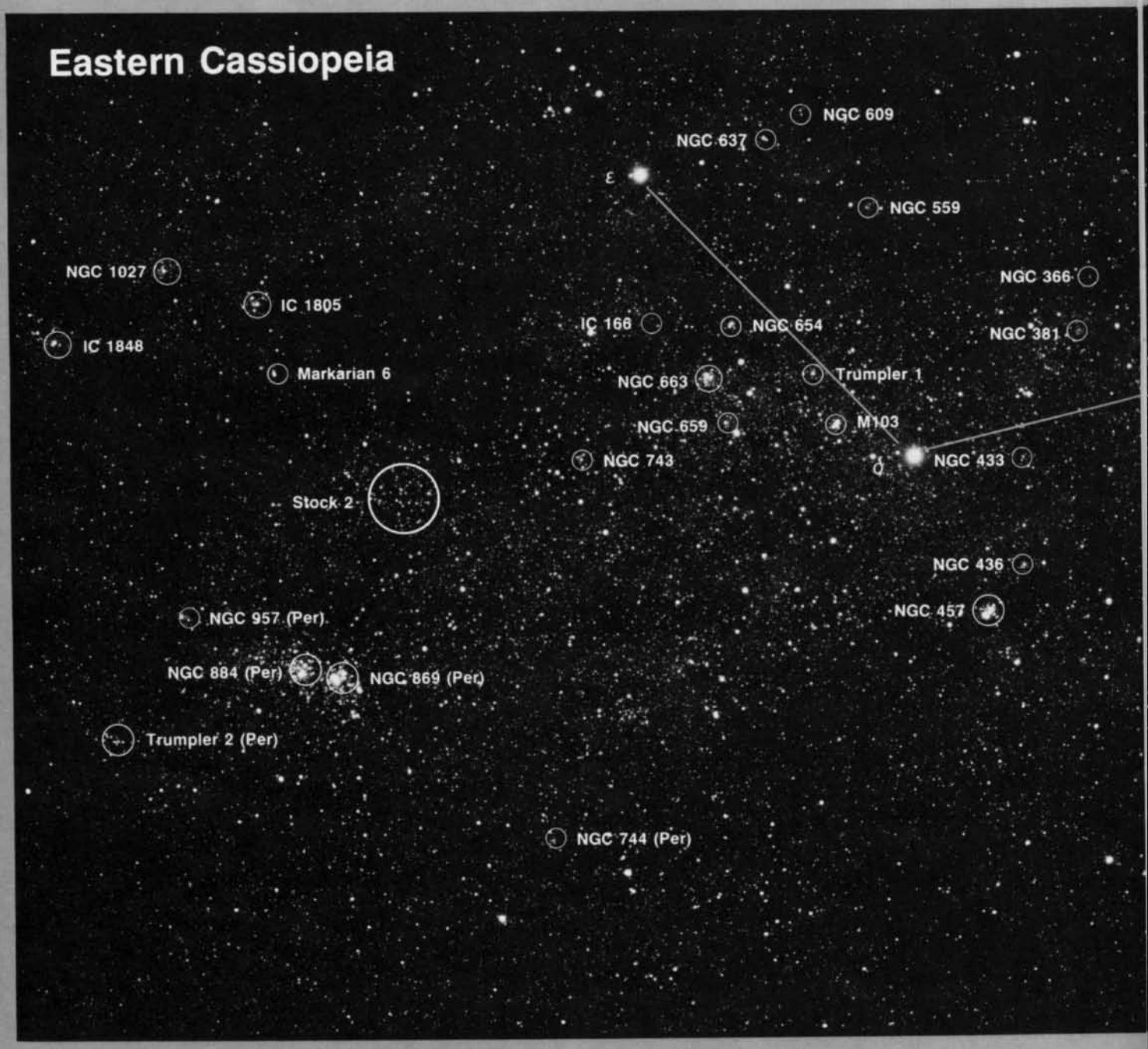


One of the most alluring regions in the sky is the constellation Cassiopeia. It isn't the brightest or the most spectacular, but I have spent many nights at the telecope observing the varied splendors of this particular area. Now well placed high in the sky toward the north, Cassiopeia offers many jewels for any observer who takes the time to hunt them out — wonderful and seemingly endless star fields, planetaries, emission nebulae, and galactic star clusters. My particular favorites are the latter — the clusters of stars that throng the plane of the Milky Way.

On the western side of Cassiopeia are four fine open clusters arranged almost in a row. From the the bright star Rho (ρ) Cassiopeiae, scan a little over 4° due north, and you'll come upon the most obvious of the four — **NGC 7788**. This group of many stars has a total magnitude of 9.4, measures 9′ across, and appears like a rich, condensed knot of stars set against the Milky Way background. Most of the member stars are fairly dim (the brightest are 10th magnitude), which gives NGC 7788 a rather ghostly appearance. If you're using a small telescope, this cluster may be a tricky target because of the background stars, but a wide-field eyepiece should provide enough sky around the cluster for a good view. In my 4¼-inch reflector with low and medium powers, NGC 7788 appears small and highly concentrated, yet it resolved well at 276x. An 8-inch reflector at 97x shows the group quite well. I have never resolved this group completely, though most of the stars are within the limit for an 8-inch; I suspect my rather light-polluted skies near Pittsburgh are to blame.

Just south of NGC 7788, in the same low-power field of view, is the open cluster **NGC 7790**. This group of 134 stars measures only 5′ across and glows at magnitude 8.5, making it conspicuous as a tiny condensation in the fabric of the Milky Way. Despite being somewhat small and compressed, I got a good view of it in my 4¼-inch, which at 42x showed a small unresolved ball of haze. Switching to 64x revealed individual stars — mostly around the edges — when I used averted vision. On a better night I used my 8-inch and got a magnificent view of NGC 7790. With 97x, the cluster's shape was basically the same as before but resolved many more stars. Since I saw a couple of dozen stars brighter than 12th magnitude, I suspect a larger reflector would resolve the entire face of this cluster.

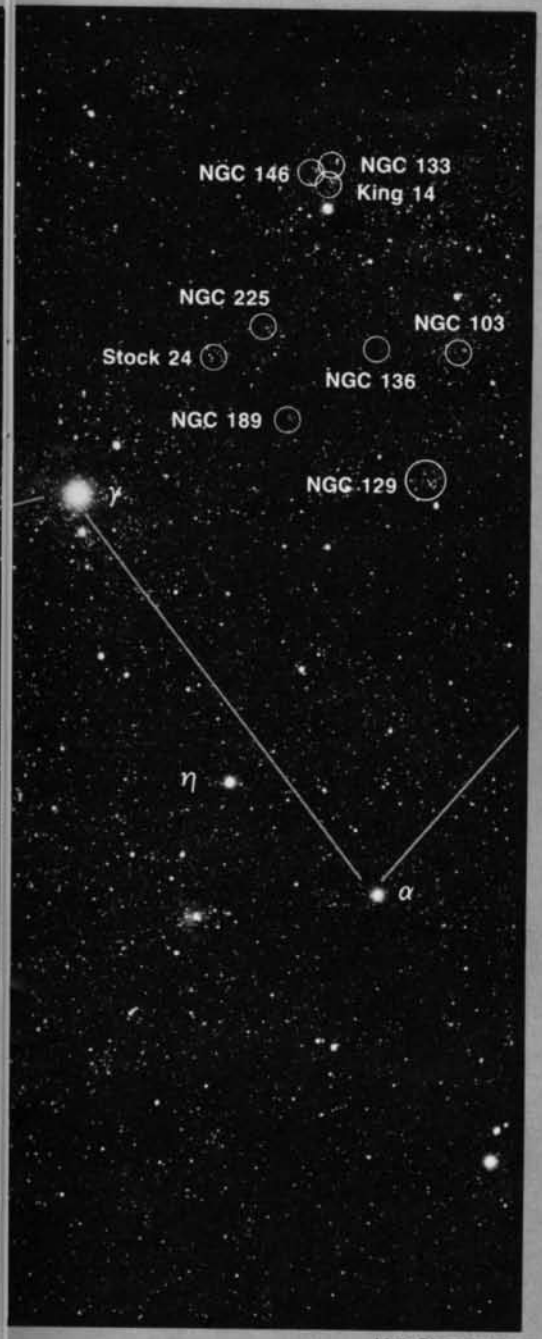
Two more clusters lie in this area. Continuing southeast from NGC 7790, we find **Berkeley 58**, a 10th magnitude group of 38 stars measuring 8′ across. This group's brightest stars shine



meekly at 12th magnitude, so you'll have to use a large telescope to obtain a satisfactory view. On the other side of the NGC 7788/7790 pair is **Harvard 21**, a poor cluster containing only 6 stars within its 4′ area. The total magnitude of the group is 9, so it is easy to spot — but you may come away with an impression much like that of the much-maligned asterism Messier 73 in Aquarius. These objects are totally lackluster!

Moving back to Rho Cassiopeiae, which forms a pair with the variable star V373, we can move the telescope south, halfway toward the bright pair of stars which includes Sigma (σ) Cassiopeiae. On a dark night, your finder scope will reveal a huge misty cloud of light — the grand open cluster **NGC 7789**. This is perhaps the most beautiful of all the galactic clusters in Cassiopeia. NGC 7789 measures 25′ across — nearly a Moon's diameter — and contains almost 600 stars, most of which glow softly at 11th magnitude and fainter. In my 4¼-inch at 64x, the entire field of view is filled with a multitude of stars. Dropping back to 42x and giving the cluster more surrounding sky, I noticed that 7789 is quite round. The great observer Sir John Herschel described this object as "a most surperb cluster, gradually growing brighter toward the center." According to astronomer Halton Arp, NGC 7789 is an ancient cluster, perhaps 1.0 to 1.5 billion years old, so the stars in it have evolved well away from the main sequence. Consequently, most members of NGC 7789 are red giants or supergiants. It lies at a distance of nearly 2 kiloparsecs, and measures 8.8 parsecs across.

In the northwestern reaches of Cassiopeia, way up near Cepheus, is the rich and stunning open cluster **M52** (NGC 7654). This is one of the nicest rich clusters in the sky, shining at 7th magnitude and packing 173 stars into its 16′ diameter. It is bright enough to see in finder scopes, and its brightest stars — shining at 8th magnitude — fill a medium-power field. An 8-inch telescope shows a smattering of faint stars, almost at the threshold of visibility, pretty uniformly distributed over the cluster. On a good night, M52 will remind you of M11, the Wild Duck Cluster in Scutum. While you're in the area, you might as well try for the faint emission object known as the Bubble Nebula, NGC 7635, which lies a degree to the southwest.



Lick Observatory

For our next three objects, start by centering your scope on the magnitude 4.2 star Kappa (κ) Cassiopeiae. From there, scan only a few minutes of arc north and you should see three clusters within the same low-power field. Slightly more conspicuous than the others is **NGC 146**, a group of 132 stars arranged in a loose circle spanning 5′. The brightest stars in NGC 146 shine at 12th magnitude, resulting in a total magnitude of 9.1. In my 4¼-inch, the group looks slightly oval and on dark nights I can distinctly see 5 bright stars. NGC 146 doesn't look very good on nights of fair transparency because of the member stars' faintness.

Just ¼° west of NGC 146 is the open cluster **NGC 133**. This is a poor group, with just 5 stars in a 7′ circle. In my 4¼-inch at 42x, it appears to be roughly

NGC 436:

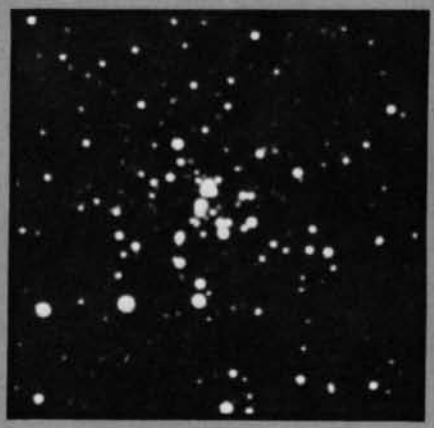
Martin Germano, 8-inch SCT, 50 minutes at f/10 on 103a-F

M103:

Martin Germano, 8-inch SCT, 30 minutes at f/10 on 103a-F

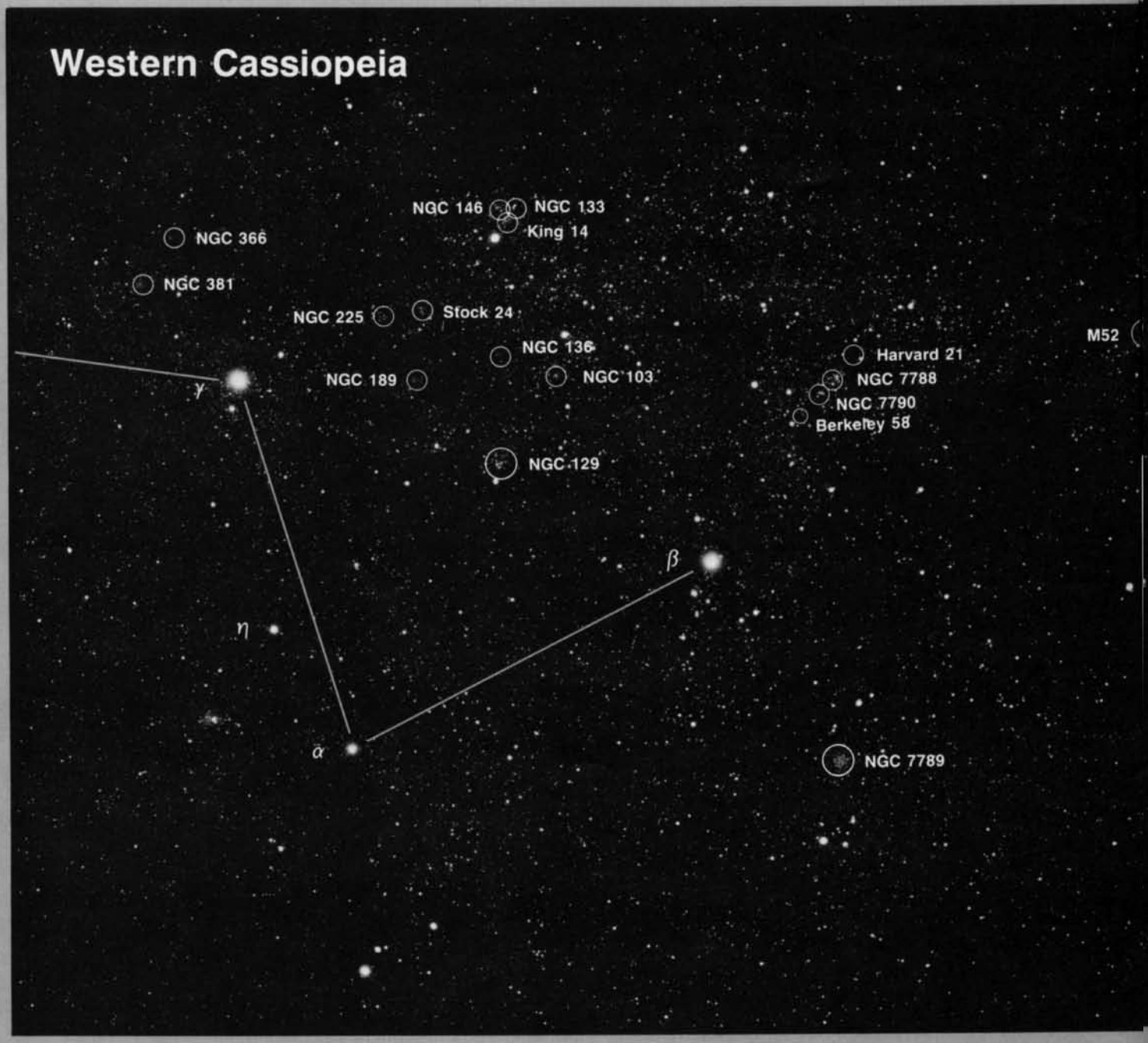
NGC 663:

Martin Germano, 8-inch SCT, 30 minutes at f/10 on 103a-F



NGC 559:

Martin Germano, 8-inch SCT, 50 minutes at f/10 on 103a-F



twice as long as it is wide, and it retains this shape at high power during good seeing. The integrated magnitude is 9.4, but this seems a bit too bright to me. In the same low-power field, back toward Kappa Cas, is the cluster **King 14**. This group has a total magnitude of 8.5 and contains 186 stars, making it a fine sight in most telescopes. The brightest star in King 14 shines at magnitude 11.3, so small telescopes on less-than-perfect nights may have trouble spotting this group. Large reflectors, however, should reveal a multitude of faint points of light.

Several nice star clusters lie within the triangle formed by bright stars Gamma (γ), Kappa, and Beta (β) Cassiopeiae. NGC 103 is a 10th magnitude group of 88 stars which measures 5′ across. It is therefore moderately concentrated — enough so that it looks like a cluster even at medium magnifications. A 4-inch shows a hazy patch of light at this location, due to the fact that the member stars are individually faint. The brightest shine at 12th magnitude, so you really need 8 or 10 inches of aperture to get a good look at this group. It is a large cluster, measuring 14.4 parsecs across, but lies 3.0 kiloparsecs away. Nearby is another rather unspectacular group of stars known as **NGC 136**. This object measures only 1.5′ across — a typical diameter for small objects like planetary nebulae — and its member stars are 13th magnitude and fainter. It contains only 20 stars, a rather small cluster, and lies at the considerable distance of 4.4 kiloparsecs. Owners of 12- or 14-inch scopes may enjoy this group of stars, but the rest of us probably won't.

Directly south of the NGC 103/NGC 136 area is the large, bright open cluster **NGC 129**. This group will not disappoint small telescope users, as it holds 193 stars — the brightest of which shine at magnitude 8.6 — in an area measuring 12′ across. It is a moderately concentrated cluster best viewed with a large field; a bright double star lies directly south of its center. An 8-inch telescope at low power provides a magnificent view of NGC 129, including several dozen stars down to 11th magnitude.

Several degrees east of NGC 129 is another group of Cassiopeia clusters. **NGC 189** is a rather poorly condensed group of 90 stars glowing at a combined 9th magnitude. Its brightest constituent stars shine at 11th magnitude, so that

Lick Observatory

a small telescope will reveal a hazy, unresolved patch of white light when you center it on this cluster. It is a small cluster which lies relatively nearby, and whose stars are intrinsically faint. The group measures 5′ across, and is easily skipped over on nights of poor transparency. Northeast of NGC 189 is a another nearby cluster, **NGC 225**. This group of 76 stars resides only 600 parsecs away from the Sun, measures 2.3 parsecs across, and thus covers a sky area of about 15′. It is poorly concentrated, but the brightest of its stars glow at 10th magnitude. This results in a combined magnitude of 7.0, making it easily spotted as a cluster in finder scopes. Also in this area is **Stock 24**, a 9th magnitude group of 180 stars of 11th magnitude and fainter.

Farther east, near bright Gamma (γ)

NGC 225:

Lee C. Coombs, 10-inch Newtonian, 10 minutes at f/5 on 103a-O

NGC 7789:

Lee C. Coombs, 10-inch Newtonian, 10 minutes at f/5 on 103a-O

NGC 129:

Lee C. Coombs, 10-inch Newtonian, 10 minutes at f/5 on 103a-O

M52:

Lee C. Coombs, 10-inch Newtonian, 10 minutes at f/5 on 103a-O

Star Clusters in Cassiopeia

Object	M#	R.A. (2000) Dec.	Mag.	B-V	Mag.*	Size	Class	Distance	Diameter	★
Berkeley 58		00h00.1m, +60°58′	9.7	0.69	11.9	8′	2Im	—	—	39
NGC 103		00h25.4m, +61°20′	9.8	0.48	12.3	5′	2Im	3.0 kpc	14.4 pc	88
NGC 129		00h29.7m, +60°14′	6.5	0.83	8.6	12′	3IIm	1.6 kpc	6.4 pc	193
NGC 133		00h31.2m, +63°21′	9.4	—	—	7′	4Ip	2.8 kpc	5.6 pc	5
NGC 136		00h31.5m, +61°32′	11.3	—	13.0	1.5′	2Ip	4.4 kpc	1.5 pc	20
NGC 146		00h33.1m, +63°18′	9.1	0.49	11.6	5′	2IIp	2.9 kpc	5.9 pc	132
King 14		00h31.8m, +63°10′	8.5	0.50	11.3	7′	3Ip	2.6 kpc	5.5 pc	186
NGC 189		00h39.6m, +61°04′	8.8	0.27	11.0	5′	3Ip	1.1 kpc	1.2 pc	90
Stock 24		00h39.7m, +61°57′	8.8	0.22	11.1	5′	3Ip	1.9 kpc	2.2 pc	180
NGC 225		00h43.4m, +61°47′	7.0	0.43	9.3	15′	3Ip	0.6 kpc	2.3 pc	76
NGC 366		01h06.5m, +62°14′	—	—	10.0	4′	2IIIm	—	—	30
NGC 381		01h08.4m, +61°34′	9.3	—	10.0	7′	3Im	2.8 kpc	6.5 pc	50
NGC 433		01h15.3m, +60°08′	—	—	9.0	4′	3IIp	—	—	15
NGC 436		01h15.5m, +58°49′	8.8	0.01	11.1	5′	1IIm	2.2 kpc	3.8 pc	49
NGC 457		01h19.1m, +58°20′	6.4	0.57	8.6	20′	2IIIr	2.8 kpc	11.0 pc	204
NGC 559		01h29.5m, +63°18′	9.5	0.35	10.6	7′	1Im	0.9 kpc	1.1 pc	120
NGC 581	M103	01h33.2m, +60°42′	7.4	0.32	10.6	6′	2IIm	2.6 kpc	5.1 pc	172
Trumpler 1		01h35.7m, +61°17′	8.1	0.25	9.6	3′	2IIp	2.2 kpc	2.9 pc	112
NGC 609		01h37.2m, +64°33′	11.0	1.31	14.4	3′	2IIIr	3.1 kpc	2.7 pc	77
NGC 637		01h41.8m, +64°02′	8.2	0.36	10.0	3′	—	1.4 kpc	1.2 pc	55
NGC 654		01h43.9m, +61°54′	6.5	0.84	7.4	6′	2IIr	1.6 kpc	2.3 pc	83
NGC 659		01h44.2m, +60°43′	7.9	0.50	10.4	6′	1IIm	2.1 kpc	3.0 pc	186
NGC 663		01h46.0m, +61°16′	7.1	0.68	8.4	15′	2IIIr	2.2 kpc	11.0 pc	108
Collinder 463		01h48.4m, +71°57′	5.7	0.59	8.5	30′	3IIm	0.6 kpc	6.4 pc	79
IC 166		01h52.5m, +61°50′	11.7	1.30	14.9	8′	2IIr	3.3 kpc	4.3 pc	179
NGC 743		01h58.7m, +60°11′	—	—	—	5′	4Ip	—	—	12
Stock 2		02h15.0m, +59°16′	4.4	0.49	8.2	45′	1IIm	0.3 kpc	5.6 pc	166
Markarian 6		02h29.6m, +60°39′	7.1	0.43	8.4	4.5′	31p	0.5 kpc	0.8 pc	29
IC 1805		02h32.5m, +61°26′	6.5	0.53	7.9	22′	2IIIm	2.1 kpc	13.0 pc	62
NGC 1027		02h42.7m, +61°33′	6.7	0.58	9.3	20′	2IIIm	1.0 kpc	5.8 pc	152
IC 1848		02h51.2m, +60°26′	6.5	0.37	7.1	12′	1IIIp	2.2 kpc	7.7 pc	74
Trumpler 3 (=H1)		03h11.4m, +63°14′	7.0	—	—	15′	3IIm	9.0 kpc	7.4 pc	30
NGC 7654	M52	23h24.2m, +61°36′	6.9	0.70	8.2	16′	2IIr	1.5 kpc	6.1 pc	173
Harvard 21		23h54.3m, +61°46′	9.0	—	—	4′	4Ip	2.8 kpc	4.0 pc	6
NGC 7788		23h56.7m, +61°24′	9.4	—	—	9′	1IIp	2.4 kpc	6.3 pc	—
NGC 7789		23h57.0m, +56°43′	6.7	0.98	10.7	25′	2IIr	1.9 kpc	8.8 pc	583
NGC 7790		23h58.4m, +61°13′	8.5	0.68	10.9	5′	2IIm	2.5 kpc	5.0 pc	134

Column 1: name in *Revised New General Catalogue*, by J. Sulentic and W. Tifft, and additional lists; **Column 2:** Messier number, if applicable; **Column 3:** coordinates for epoch 2000.0; **Column 4:** integrated magnitude in V system; **Column 5:** integrated color — the higher the number, the redder the object; **Column 6:** integrated magnitude of cluster's brightest star; **Column 7:** angular diameter in arcminutes; **Column 8:** Trumpler Class. This catagorization consists of three sets of information; 1 - 4 equals decreasing central condensation or detachment from the background; I through IV indicate increasing range in magnitude of cluster stars; letters r (rich), m (medium), or p (poor) indicate relative populations of the cluster; **Column 9:** distance in kiloparsecs; **Column 10:** linear diameter in parsecs; **Column 11:** number of stars.

Cassiopeiae, are the clusters **NGC 366** and NGC 381. NGC 366 is a grouping of 30 stars of 10th magnitude and fainter, compressed into a 4′ area. It is moderately concentrated and appears like a fuzzy spot of granular nebulosity in small telescopes. **NGC 381** is considerably larger and richer, shining at 9th magnitude and containing some 10th magnitude stars. It measures 7′ across and contains 50 stars.

South of the Gamma Cas area are three more bright clusters. **NGC 433** is a poor specimen, showing up only as a condensation in the density of stars in Cassiopeia's Milky Way. It holds 15 stars — some of which shine at 9th magnitude — in an area 4′ across. This cluster is decidedly unimpressive, and becomes only marginally better when viewed with a large telescope. **NGC 436** is much nicer, as it measures 5′ across and contains 49 stars. This cluster shows up well in finder telescopes — its total magnitude is 8.8 — and makes for an attractive sight in small scopes.

Still better is **NGC 457**, one of the best non-Messier star clusters in the northern sky. NGC 457 shines at 6th magnitude and measures 20′ across, so it is a fine sight in binoculars as well as telescopes. A rich cluster, it contains 204 stars and is sometimes called the "Owl Cluster" because of the unusual wing-shaped arrangement of bright stars within the group. NGC 457 lies at a distance of 2.8 kiloparsecs: it is impressive because it is a very large open cluster, measuring 11 parsecs across. Its brightest star, Phi (ϕ) Cassiopeiae, shines at 8th magnitude, making it one of the most luminous stars known in the Galaxy.

The heart of Cassiopeia's Milky Way, represented by the area between Delta (δ) and Epsilon (ε) Cas, holds 10 bright clusters. Just two degrees northeast of Delta is **M103** (NGC 581), a rich clustering of 172 stars of 10th magnitude and fainter in only 6′. This is one of the best clusters in the area, instantly recognizable in finders due to its high density of bright stars. North of M103 is **Trumpler 1**, a rather sparse, 8th magnitude group of stars only 3′ in extent. East of this area are the clusters **NGC 654, NGC 659,** and **NGC 663**. All three are relatively bright, rich clusters easily visible in small telescopes and impressive because they contain large numbers of bright stars. **IC 166** is an unusual, faint group shining at just 12th magnitude and composed of stars no

brighter than magnitude 14.9. It contains 179 stars, however, in a circle spanning 8′: can large-scope owners spot this elusive star cluster? **NGC 743** is a poor cluster containing only 12 stars — it may not be a true open cluster at all.

Three fine clusters lie up to the north, nearly due west of bright star Epsilon. **NGC 559** is a moderately condensed bright cluster which contains 120 stars of 10th magnitude and fainter, packed into a 7′ area. Smaller and richer is **NGC 609**, a faint star cluster shining at 11th magnitude and containing 77 stars of 14th magnitude and fainter. This object is a difficult one on poor nights, and will require large telescopes to detect as anything more than an ill-defined haze. **NGC 637** is a brighter group, shining at a combined 8th magnitude.

The far eastern reaches of Cassiopeia — territory just north of the Double Cluster in Perseus — contains our final five clusters. The closest cluster to us in Cassiopeia, at some 300 parsecs, is **Stock 2**, and it is consequently the largest — some 45′ across. Its members shine at magnitude 8.2 and fainter, giving the group a combined magnitude of 4.4. Binoculars and finder telescopes provide the best view of Stock 2's 166 widely scattered stars.

Two large complexes of emission nebulosity, IC 1805 and IC 1848, are home to two star clusters evolved out of the nebulosity. **IC 1805** has a star cluster, often called Melotte 15, which shines at magnitude 6.5, measures 22′ across, has 62 constituent stars of 8th magnitude and fainter, and is moderately compressed. Compare the two, which are similar: **IC 1848** shines with the light of a magnitude 6.5 star, measures 12′ across, holds 74 stars of 7th magnitude and fainter, and is rather loose. Located between the two emission nebulae is **NGC 1027**, a bright cluster 20′ across and containing 152 stars. South of IC 1805 is the tiny cluster **Markarian 6**, a poor group of 30 stars spanning 4.5′ across and glowing at 7th magnitude.

If you want to look at many, many star clusters, you'll want to explore Cassiopeia. We've detailed 37 of the best in this rich section of the Northern Milky Way; now it's your turn to go out and get your own eyepiece impressions of these brilliant groups. These clusters are satisfying regardless of your telescope — in fact, some are best viewed in binoculars and finder telescopes! Enjoy your viewing and let *Deep Sky* know how you did with them. Happy hunting!

James Garasich, an experienced deep-sky observer specializing in star clusters, is an astronomy student at the University of Pittsburgh and an observer on Allegheny Observatory's 30-inch Thaw refractor. He wrote many articles for the original Deep Sky Monthly.

NGC 659:

Martin Germano, 8-inch SCT, 50 minutes at f/10 on 103a-F

NGC 654:

Lee C. Coombs, 10-inch Newtonian, 5 minutes at f/5 on 103a-O

Harvard 21 and NGC 7788:

Martin Germano, 8-inch SCT, 40 minutes at f/10 on 103a-F

NGC 637:

Martin Germano, 8-inch SCT, 35 minutes at f/10 on 103a-F

DSM Reviews

Telrad Findersight
Steve Kufeld
List price: $36.95
[available from: 7092 Betty Drive, Huntington Beach, CA 92647]

One of the biggest problems in deep-sky observing is knowing where to point your telescope. Finder telescopes are generally useful for locating objects, but their inverted, magnified images often confuse beginners not intimately familiar with star-hopping. Because of this, many observers sight along the telescope tube or finderscope thumbscrews to initially point the telescope, so that the object of interest is in or near the field of the finderscope.

This problem is completely solved by a device called a Telrad finder sight, a device consisting of a small plate glass window tilted at a 45° angle with respect to the telescope tube. The Telrad projects an illuminated reticle of three concentric rings onto the underside of the window, which in turn reflects the reticle into the user's eye. The result is that you see the real sky with the virtual image of the three target rings projected on it, which makes pointing the telescope as simple as centering the object or area of interest within the rings. The largest ring represents 4° of sky, while the smallest shows ½° and represents a typical telescopic field of view. The rings are adjustable in brightness by means of a rheostat, making the finder useful for both dark-sky and city observing.

If you use a small, rich-field telescope like a Celestron Comet Catcher, you will find that no finderscope is needed with the Telrad, since the telescope's field of view is over 2 degrees. With a larger telescope, such as a Coulter Odyssey, the Telrad may be used in conjunction with a finderscope to make finding things easy.

The Telrad does have some problems, however. Its plate glass window, being completely exposed, tends to dew up on moist evenings. In addition, it has a fairly bulky design and is constructed of a cheap molded plastic.

In spite of this, however, the Telrad finder scope is the easiest, most convenient finding aid I've used. I highly recommend this innovative observing device. *Gary Kinsman.*

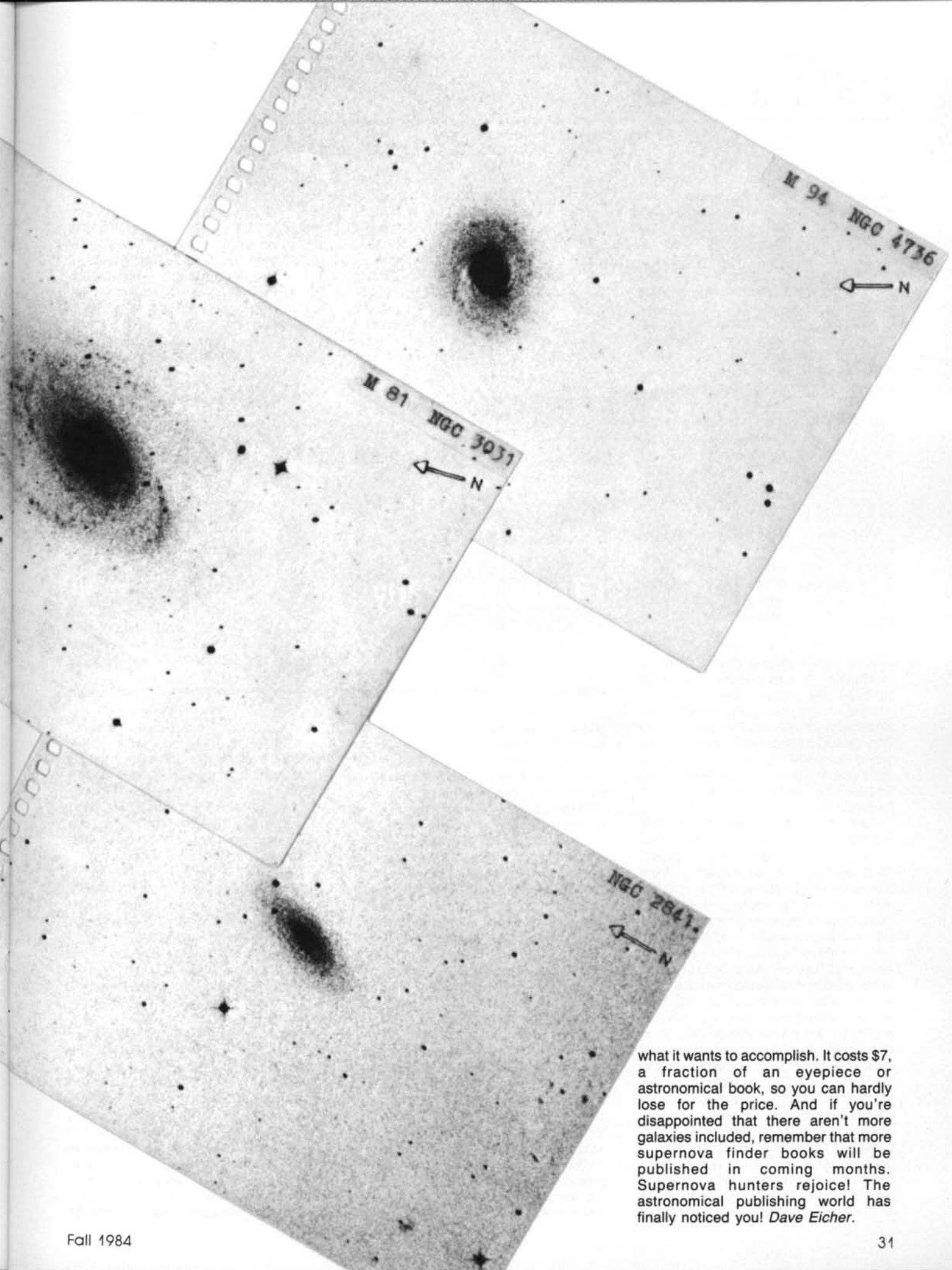
Check a Possible Supernova
photographs of galaxies
by Juhani Salmi
40 cards, spiral bound, $6.95
JS Observatory (1984)
[publisher's address: Vesijarvenkatu 36 C 40, SF-15140 Lahti 14, Suomi, Finland]

As I write this, the Reverend Robert Evans of Maclean, New South Wales, has just discovered his sixth extragalactic supernova this *year*, this time in the galaxy NGC 991 in Cetus. This is a remarkable feat, as Evans has discovered the distant exploding stars visually — with his homemade reflector — and beat professional astronomers using photographic techniques to the punch. This is encouraging for backyard observers who want to contribute something to astronomical discovery, and Evans' dogged persistence seems to coincide with an increasing interest in supernova hunting. Indeed, at least three books or atlases are planned for publication during the next few months, one of which is the handy *Check a Possible Supernova*.

Supernova is a wire-bound collection of 40 5¾″ x 4⅛″ finder cards, each printed on card stock and overcoated to protect against moisture when used at the telescope. There is one galaxy field per page, photographed with a 12-inch f/6.4 Newtonian and 103a-O emulsion between 1980 and 1983. The exposures generally lasted between 15 and 30 minutes, providing good definition of the nebular light but not overexposing areas where "guest stars" may pop up. The scale varies significantly — M51 appears as large as M33, for example — and north is indicated by an arrow. All of the reproductions are halftones of negative prints, and they are reproduced quite well.

A 1984 analysis of 201 supernova events in bright galaxies, conducted by Brian Skiff of Lowell Observatory, shows that fully 66% of observed supernovae occur predominently in mid and late-type spirals: Sb through Scd galaxies. In *Supernova*, many good candidates are present, such as M33, M51, M100, M101, NGC 6946, and NGC 7331. But also present are some lenticulars and early-type spirals, which are comparatively "low-risk" galaxies in terms of producing quantities of supernovae, and edge-on galaxies, which are more likely to hide supernovae behind thick expanses of interstellar dust.

Probably the greatest asset of this book is that it is handy. You can slip it in a pocket and have it right at the telescope, ready to check innumerable field stars, all night long. It provides field stars for only 40 objects — you sure wish there were more of these things — but it does a reasonably good job at



what it wants to accomplish. It costs $7, a fraction of an eyepiece or astronomical book, so you can hardly lose for the price. And if you're disappointed that there aren't more galaxies included, remember that more supernova finder books will be published in coming months. Supernova hunters rejoice! The astronomical publishing world has finally noticed you! *Dave Eicher.*

DSM Reports

Seeing Double at the Texas Star Party

Lee Cain and his 17.5-inch binocular telescope. Photo by Richard Berry.

Revelations — suddenly seeing what you have not seen before — are rare enough that they deserve note. I have experienced perhaps a dozen in my life, five or six of them in the field of astronomy.

The first happened when I was in sixth grade, and someone, probably the school nurse, prompted an eye examination. Lo and behold, they found me to be very nearsighted. With eyes focused five inches in front of my face, I'd probably never been able to read the blackboard in my life! I vividly remember riding home to Stamford from the optometrist's office in Yonkers, New York. The raw shock of seeing so much, things that I'd never seen before, counts as revelation: a red-breasted robin pulling a worm from the ground, every segment visible, every feather on the bird clear and sharp.

Discovering sight at age eleven undoubtedly helped get me hooked on the stars. I had always been interested in astronomy — as an avid reader — but being able to *see* them made my learning the constellations, with the aid of Barton and Barton, feasible.

A year or so later my Dad and I carried the mountless 6-inch reflector he'd made several years earlier down from the attic, washed the dust off the cracked mirror (that's another story) — and that night I saw Jupiter and Saturn. Tiny gems floating in the void; another vision powerful enough to get an impressionable twelve-year-old hooked on astronomy, optics, and telescopes.

Perhaps we get jaded with age, but I don't think so. I was 23 when I first encountered truly dark skies. Discovering the Milky Way from northern Ontario led me, for the next five years or so, to explore that grand panorama of clusters, starclouds, and nebulae in every way I could — mostly with cameras. I used cameras, most often a 24" Aero-Tessar, because dark skies were all too seldom available, and a night or two of moonless photography meant I could give myself a month's worth of Milky Way observing, albeit vicarious, in the darkroom. Photos, of course, can be contrast-enhanced to reveal features hardly visible to the eye. Sometime early in that period I also discovered an intact copy of E.E. Barnard's *Photographic Atlas of Selected Regions of the Milky Way* in the University of Toronto library. That, too, was a revelation of beauty and structure I'd never dreamed existed in the sky. E.E. Barnard guided my efforts to photograph the Milky Way as surely as if he'd written the book for me alone.

The reason I'm writing this preface is to explain first, I suppose, that I don't take seeing for granted, and, second, that I'm something of a nut on the Milky Way. Calibrate, if you will, what follows by those yardsticks; I'll grant that I am enthusiastic, but I don't think I am overly so.

Anyhow, it happened at the 1984 Texas Star Party. I had spent the late afternoon and evening with Ed Boutwell, at his Edmond Halley Observatory situated on a little ridge above the Prude Ranch, and was thoroughly dark-adapted. I'd had my first good look at Omega Centauri through the 16-inch Newtonian Ed has there in the observatory, and we'd piled into his van and driven down the rather steep and rocky access road without turning on the headlights. Ed dropped me and several others at the foot of the hill, and I tromped off across the observing field, back toward Walnut, where I was staying. At this juncture, please note that I've set the scene for a dramatic revelation which follows, slightly rewritten but based my article in *Telescope Making* #23 (ahem).

I don't know whether it was destiny, or merely happy accident that I stumbled across Lee Cain's binocular as I made my way toward the dorms, but the two hours I spent observing with Lee Cain's 17.5-inch binocular was, for me, a revelation of what deep-sky observing can be.

The instrument had attracted a small crowd, so I waited patiently in the line for my first look. The line dwindled; finally the person in front of me finished and stepped aside. I adjusted the separation between the eyepieces — the mechanically easy task of rotating the diagonal assemblies of the two telescopes until the image circles blend — then focused each eye separately.

The sky seen through the binocular appears as a bowl or dish concave toward the observer, and about one-fourth as deep as it is wide. This effect occurs, Lee says, because of field distortion in the 24mm TeleVue Wide-Field eyepieces. As I scanned, stars did not cross the field in a straight line, but seemed to pinch slighly inward, creating the bowl effect. It was not unpleasant.

But *what* I saw defies description. With big telescopes, random scanning is not usually rewarding; with the binocular, it was. Starclouds, faint "photographic" nebulae, dark nebulae, Bok globules — they were all there. For quality and sheer realism, the universe seen with two eyes exceeds any monocular image I've ever seen.

The binocular view is not a three-dimensional image, or at least that is not the dominant impression. Rather, it is the visibity of subtle contrast and detail which disappears for one eye, but shines with two, that is so stunning. I don't remember what the first object I saw was because I saw so much in the next couple hours.

As I scanned the binocular across the region of the galactic center, I began, rather modestly, looking for some dark nebulae I had observed two nights earlier with Dana Patchick at Riverside. I remembered roughly where they were, and figured I would run across them if I simply searched.

But the problem soon became an

embarrassment of riches: which of the many dark nebulae visible were the ones I'd seen before? Scanning revealed dozens of dark nebulae — though I did eventually find both I sought. I happened across the Parrot Head, B87, recognizable by its shape, lots and lots of long dark streamers, and fields nearly devoid of stars.

Particularly exciting to me was seeing, with my own eyes, the rich fields that Barnard had captured on his plates 79 years before. I was seeing what I thought I would never see — *seeing* the glow of tenuous wisps of hydrogen between the stars, *seeing* the glint of starlight reflected from clouds of dust, *seeing* the inky drops of stellar formations, *seeing* the vast seamless fabric of Milky Way.

material illuminated by starlight. The big lane coming out from 22 Sco, B44, is not a uniform black, but shows subtle modulations in an over-all dark gray tone. I followed this lane east until it petered out in disconnected blobs.

In the Sagittarius Star Cloud, the sky was aglow with myriad faint stars. Here I happened across the bright open cluster NGC 6520, memorable because of an adjacent dark nebula, B86. This was one of the objects I'd seen through Dana's telescope at Riverside. Just scanning, I also picked up B90.

By the way, I want to give credit to those great TSP skies in seeing all this stuff. I use the visibility of the Galactic Dark Horse as a measure of sky quality. This 10° complex of dark nebulae shows up beautifully wide angle Milky Way

had a splendid view, but the subtle impression of the nebular glow as grainless, smooth, silky, and fluid, and the ability to discern the faint western extensions of the nebula, were gone. The sight was indescribably REAL with two eyes.

Despite its brightness, I did not notice notice color in the Lagoon, so I was all the more surprised, when I swung the scope up to the Trifid and its companion reflection nebula, to see the Trifid as pink (not red) and the companion reflection nebula as a pale blue. I still cannot explain why I could see color so distinctly in this pair but could not see it in the brighter Lagoon. I even went back to the Lagoon and looked for color but it was not there. Perhaps its visibility had something to do with the color

Star cluster NGC 6520 and its neighbor dark nebula Barnard 86. Photo by Brian Skiff.

"Berry's Galactic Dark Horse," located on the Sagittarius/Ophiuchus border. Photo by Richard Berry.

The Lagoon and Trifid Nebulae: from Texas, color is routine. Photo by Al Lilge.

Since I didn't have any star atlas with me, I can't begin to identify everything I saw. I scanned a good part of southern Ophiuchus, including the enormous dark lanes of dust that extend eastward from the Antares Hexagon (Rho Oph, Omicron, 22, Sigma, and Alpha Sco, plus M4). Working from memory, I tried to find Barnard 72, the famous "S" nebula, but couldn't. I knew it was somewhere near Theta Oph, but didn't remember whether it was north or south, and since I remembered it as being south, I biased my search in that direction. Unfortunately, it lies to the north.

However, to the south of Theta is Barnard 78, the hindquarters of the Galactic Horse, shown on plate 21 of the *Atlas*, and it filled several fields. When the binocular was centered on it, the 7th magnitude star Barnard labels as 405 shown forth in a nearly blank field. I went looking for a totally blank field, but the best I could do was one with a single 12th magnitude star in the Northern Antares Dust Lane, near 16h 40m −24°, probably the western end of B45.

The most remarkable aspect of these dust lanes were the visibility of the edge-brightening effects and glow of dark

shots. (You've never heard of the Horse? His head, B259, is at 17h30m, −18°, with B270 serving as his ears; his raised foreleg, B63, is at 17h15m, −22°; his straight foreleg consists of B57, B60, B67, B246, B253, and B257; his neck is B266 and 268; his body is made of B77, B262, B269, at 17h30m −24°; and his flank and hind leg are B59, B65, B66, B67, and B78, centered at 17h20m, −26°.) He photographs without difficulty — almost any 35mm camera piggybacked 5 minutes will do. When BGDH (Berry's Galactic Dark Horse) is visible to the naked eye, the skies are *good*. In Texas, if you knew he was there, you couldn't miss him!

Those Dark Horse fields, incidentally, were the areas that had been my favorites when photographed with the Aero-Tessar. Among the bright objects we observed was the Lagoon Nebula, which spilled across the field far brighter than any part of the brilliant Milky Way. It looked like a shining fluid enveloping the star cluster embedded in it. Minute runs of dark stitchery crossed it — these dark nebulae also show up in the photographs. Missing was that "graininess" so characteristic of dim-light seeing. I closed one eye and still

contrast between the Trifid and its companion, a contrast which is lacking in the field of the Lagoon.

The dark nebular complex around the Trifid was also immediately visible. I did not expect to see these dark nebulae any more than I had expected the color; if I had not seen these phenomena, I doubt I would have thought to look for them. Nor would I have readily believed that what I saw could be seen if someone else told me that they had seen it.

I also spotted some faint emission nebulae a degree or so east of the Lagoon. This appears to be NGC 6559 and some related faint fuzzy stuff around several nearby stars. It is difficult to tell sometime whether a particular glow is background starlight shining through a ring of dark nebulae, or whether it is genuinely a brighter region.

We also looked at the Cygnus Loop, another unforgettable experience. As I scanned the binocular around it, what struck me once again, with considerable force, was the "milky fluid" appearance of bright nebulosity, and the fine striations. I've seen these from Wisconsin, but never through a giant binocular. I tried closing one eye.

Though the view was still impressive in those dark skies, the grainless appearance seems to require both eyes.

So then what is the role of the second eye? In a word: confirmation. Lee says, "The brain believes what it sees with two eyes." A second image, even one of markedly inferior quality, provides the brain with confirmation of the reality of features in the first; this increases the confidence the brain places in the reality of the image.

In the ordinary daytime world, the brain does a lot of "filling-in" for the eyes, so on familiar objects the monocular view is nearly as good as the binocular view. Lee has talked to optometrists and opthalmologists about the mechanisms of vision and image interpretation in the brain. According to them, we are wired for binocular vision. In a two-eyed world, the brain rejects one-eye phenomena like "floaters" because they are seen with one eye only — unconfirmed sightings, as it were. On low-luminosity images of unfamiliar objects, the system edits out or ignores features of the image in which it has the least confidence, usually the faint stuff near the threshold of visiblity.

The brain-processing of ocular images produces other effects, too. "When I look at Omega through a monocular telescope like a C-11 or John's 12-inch, it seems to boil and writhe," said Lee. "That might be the brain looking for some pattern, but the brightness of the stars at the limit of the 12-inch mirror is near enough to threshold that the brain won't quite believe them, so it shuffles around a little bit." We looked up at the stars again. "The field of view the binocular produces," said Lee, "is solid. It's stable, it doesn't flicker."

Building an 80x450 binocular is not my next and immediate goal. Lee's binocular cost him roughly $2500, which is a lot. And the role of those inky black Texas skies cannot be ignored. From my backyard in urban Milwaukee, I would not expect much dramatic observing — no revelations there!

As for the building a binocular, all that's required is careful workmanship. Lee built his binocular with handtools from plywood, aluminum pipe, Formica, and Teflon. Incidentally, if you're not a telescope builder yourself, don't misplace Lee as the typical super-dedicated specialist long-time telescope maker. He's not. But Lee is a truly original telescope maker, i.e., someone who isn't a "telescope maker" at all — instead he's a person who happens to have built some telescopes. Coming to the field as an outsider, he knew very little to begin with, and not being blinded by what he "knew", set out to do what the old hands regard as impossible. More often than not, the major advances in telescope making have come from such outsiders; we long-time TM nuts owe them a debt of gratitude.

And Lee isn't exactly your seasoned observer, either. He enjoys having more experienced observers show him what can be seen through his telescopes. Lee mentioned that he has been using the Telrad finder on his 17.5-inch binocular to learn where to look for things after he'd been shown them through the telescope. This may strike dedicated observers as slightly weird, perhaps, but it's a perfectly sensible way to do things.

So there you have it. I had my revelation, and being a writer, I've written about it. Lee sold his binocular to an optometrist in the Houston area, and is presumably planning to go on to bigger and better things — or perhaps smaller and better things. I asked Lee what improvement he thought the 17.5-inch binocular offered over his thirteens. He said, "Not much. If I were doing it again, I think I'd stick with 13-inchers." He also pointed out that a reflecting binocular smaller than 10" would leave too little room for the observer's head between the tubes, at least based on his design.

Having experienced it, I'm convinced there's nothing like RFT binocular viewing under dark skies. Curiously, in reminiscing about Riverside Telescope Makers Conference, I realized that Jim Jacobsen had given a talk on visual high fidelity. He had defined its nemesis, visual distortion, as the following: 1) having too little light to fill the eye's pupil, which dims the view; 2) seeing the Airy disk, which makes the stars appear spuriously large; and 3) viewing through telescopes with one eye only, which our eyes and brain are not designed to do.

Jim's remarks seem particularly apt in retrospect: "There really is a paradox about the way we see the universe today. We use our instruments to look at the universe, but the way we look at the universe determines the way we look upon it." Yes, he is correct. My view of the universe, or at least my appreciation of the wonderful structures in our Galaxy, were reshaped by those hours with Lee's telescope.

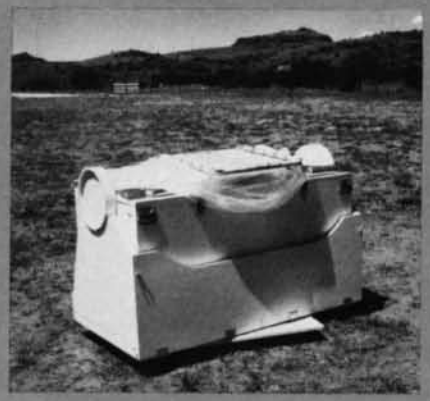
"John Dobson told me," continued Jim, "that he thinks the best way to see the universe would be to lie on your back on a platform on top of a palm tree on an island in the middle of the Pacific." Viewing from a dark sky, the Earth out of sight, would allow us to gaze outward and see the thing for itself, undistorted. He continued, "Our aim in observing is eliminate the distortions, or at very least, to aim toward fewer distortions."

In visual high fidelity, the telescope disappears.

"We're interested in normal field brightness telescopes — those that have a 7mm exit pupil." Jim also mentioned binoculars which, he said, "provide some of the best views we have," and described how, as a boy, he had visited an older cousin who was an amateur astronomer. What he remembers vividly is his cousin's advice, "always try to view the universe with your two eyes." I couldn't agree with him more. — *Richard Berry*.

The Veil Nebula: filamentary structure like "milky fluid in space." Photo by Al Lilge.

Barnard 72, the "S" Nebula in Ophiuchus. Photo by Al Lilge.



The binocular telescope folds down into one neat package after a night's observing. Photo by Richard Berry.

Double Stars

Exploring Andromeda in Autumn

by Glenn F. Chaple, Jr.

I don't know about you, but I'm awfully glad autumn has arrived. Astronomically speaking, the summer of '84 here in New England was "the pits." If it wasn't cloudy, it was hazy. If skies were clear, there was a Full Moon. I had to study the astrophotos in *Deep Sky* just to remind myself what nebulae and galaxies looked like.

I shouldn't have to much longer. With the coming of autumn, cool Canadian air should begin sweeping down across much of the U.S., ridding us at last of the heat and haze. To celebrate a return to dark, star-filled nights, let's set up our telescopes and check out the double stars that reside in one of the best-known autumn constellations — Andromeda.

To most telescope owners, Andromeda means one thing — the great spiral galaxy M31. Even with my bias toward double stars, I'll concede that this is the finest sky object in the region. But anyone who leaves Andromeda after having viewed just M31 has missed one of the most colorful double stars in the heavens. The pair I'm referring to is **Gamma** (γ) **Andromedae** — a stunning gold and blue-green twosome that rivals the celebrated Albireo in beauty.

Gamma Andromedae — also known as Almach — is one of those double stars that offers something for telescopes of all sizes. It's magnitude (2.5 and 5) and separation (10″) make it easy for small scopes. Even the beginner with a 2.4-inch refractor fitted with a 60x eyepiece will enjoy a fine view of this celestial beauty. Experienced skywatchers with scopes of 8 inches aperture or more (preferably long-focus instruments like refractors and catadioptrics) should carefully study the secondary star, using the highest possible magnification. Gamma B is an extremely close and difficult binary with a period of 61 years. Right now, the components of Gamma B are about as far apart as they can get — a separation of just 0.6″. Back in 1980, I managed to elongate this system with a 6-inch Alvan Clark refractor and a magnification of 360.

You often read that the colors of bright double stars seem more vivid when viewed through small-aperture telescopes, and this seems to be the case with Almach. In my trusty 3-inch f/10 Edmund reflector, the colors are exquisite. Viewed through the 6-inch Clark, however, Almach's colors seem rather washed out. If you own both a small and a large telescope, compare Almach's hues. Do you get the same results I did?

If you direct a pair of binoculars at the area 5° south and slightly west of Almach, you'll see two things — the open star cluster NGC 752 and, on its southwest edge, the wide pair **56 Andromedae**. The double is a chance alignment of two sixth magnitude stars that currently lie about 190″ apart. Double stars with such ample separations always look best in the low-power fields of binoculars and finderscopes. Both members of 56 Andromedae have a spectral class of K, which means that they should shine with a golden yellow hue. However, my 7 x 50 binoculars show little, if any, coloration. My 3-inch reflector at 30x seems to do the trick and, in the process, allows a close-up glimpse of NGC 752. The cluster is quite sparse, but it contains one nice triple star and several pairs.

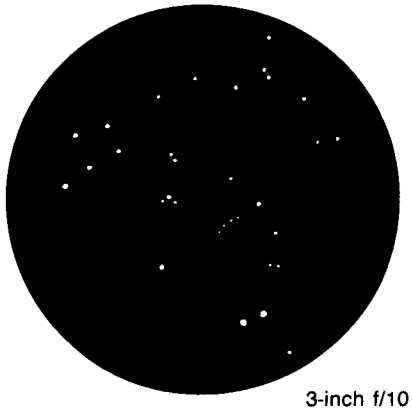
Three degrees to the northeast from 56 Andromedae is the pretty double star **59 Andromedae**. This relatively fixed duo sports component stars of magnitude 5.6 and 6.1, placed 16.5″ apart. Here again is an easy target for small-aperture instruments. Both stars have an A-type spectrum and appear white.

Another fine small-scope object is the unequal double **Pi** (π) **Andromedae**. The lesser component is over sixty times fainter than the primary and would be extremely hard to see were the two stars a lot closer together. Thanks to a 36″ separation, you'll have no trouble seeing both. Try averted vision if you can't see the companion star. No orbital motion has been detected for Pi Andromedae, but the two stars share a common proper motion — strong evidence that they form a gravitationally-bound system.

Less than a degree west of Eta (η) Andromedae is the interesting binary system **36 Andromedae**. For the half century prior to 1980, this magnitude 6.2 and 6.7 pair was never separated by more than 0.6″. The two stars are opening up now, and a current separation of 0.8″ makes them *just* resolvable with a good 6-inch scope under optimum sky conditions. If you own a 3- or 4-inch scope, be patient. Thirty-five years from now, 36 Andromedae will be near its maximum separation of 1.4 arcseconds.

For every binary star that's widening, there's one that's closing together. Thus, we balance 36 Andromedae with the binary pair **Σ3050**. This twin system is located 5° north and slightly west of Alpha (α) Andromedae, quite close to the celestial prime meridian, zero hours right ascension. A century and a half ago, you could have picked off Σ3050 with a 2-inch refractor — the two stars were nearly 4″ apart then. By 1935, orbital motion had cut that separation in half. The two stars are currently 1.5″ apart and make a stern resolution test for 3-inch telescopes. The orbit of Σ3050 hasn't been determined with any degree of accuracy — the period seems to be about 800 years — so it's hard to say just how close the component stars will get. Suffice it to say that if you want to split this pair, do it now!

NGC 752 and 56 Andromedae



3-inch f/10 reflector
Sketch by Glenn F. Chaple, Jr. 360x

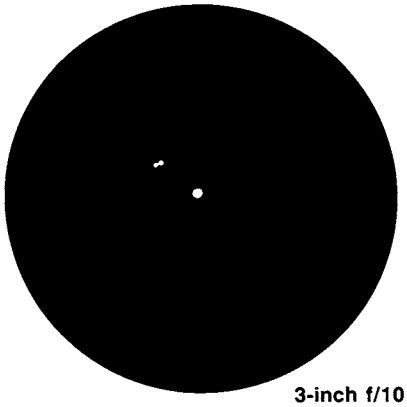
Star	R.A. (2000)	Dec.	Mags.	Sep.	P.A.	Year
Σ3050	23h59.5m	+33°44′	6.5, 6.5	1.5″	309°	1980
Pi (π)	0h36.9m	+33°43′	4.4, 8.7	36.1″	174°	1937
36 (Σ73)	0h55.0m	+23°38′	6.2, 6.7	0.8″	300°	1984
56	1h56.2m	+37°15′	5.7, 5.8	190.0″	300°	1928
Gamma (γ)	2h03.9m	+42°20′	2.3, 5.5, 6.3	10″,0.6″	63°,110°	1962, 1984
59 (Σ222)	2h10.9m	+39°02′	5.6, 6.1	16.6″	35°	1923

Double Takes — Here's a note to those of you who never subscribed to *Deep Sky Monthly*, the forerunner of this magazine. If you enjoy double star observing and have gleaned useful information from this column (I hope so!), I encourage you to pick up some back issues of DSM. A complete list of the ones that are available appears on page 2 of this issue. This column was a regular feature of DSM, and we've looked at hundreds of fascinating pairs, triples, and multiple stars since I began writing for DSM back in 1977. If you'd like to know which issue contains information on a particular double star or double stars contained in a certain constellation, drop me a line.

Have you ever wondered what colors a certain double star displays? Your handbook says yellow and blue. You see orange and white, while a friend swears it's red and green. Thanks to the vagaries of the human eye, double star colors are always subject to dispute. Don't despair! Help is here in the form of a new publication titled *A Color Catalogue of Double & Multiple Stars Based on Human Color Perception*. This Webb Society publication is a result of five years of work by Joseph Kaznica, James F. Russell, Jr., Sandra T. (Keen) Kaznica, and Billie Westergard. They used the 24-inch Cassegrain reflector at the Mount Cuba Astronomical Observatory located near Wilmington, Delaware, to photograph and analyze the colors of 200 well-known stellar partnerships. The photographic work was compared to visual color perceptions to produce the final results. For their work, these diligent amateur astronomers were awarded the 1982 Webb Society award. You can get a copy of the catalogue by mailing $4.50 to Joe Kaznica, 29 West Bellamy Drive, Whitehall, New Castle, DE 19720. You might want to ask Mr. Kaznica about the Webb Society — a British-based group that has an active double star section.

82 South Harbor Road
Townsend, MA 01469

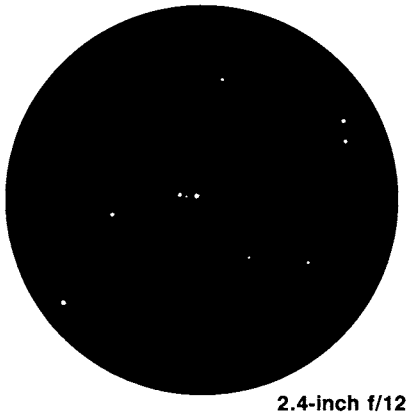
γ Andromedae



3-inch f/10 reflector 360x

Sketch by Glenn F. Chaple, Jr.

59 Andromedae



2.4-inch f/12 refractor 60x

Sketch by David Foss

Variable Stars

Ode to Autumn

by David H. Levy

With cooler and drier weather coming, autumn is an excellent time to begin or resume a program of variable stars. Let's outline a simple program for fall observing — a list of stars of different times, magnitudes, ranges, and ease of finding.

Two Stars of Long Period

As the prototype-star of its class, **Mira** (Omicron [o] Ceti) is a natural choice to begin our autumn voyage. Even at its minimum, which can be as faint as 10th magnitude, this star is easy both to find and to estimate. In 1603, when David Fabricius noticed that it changed brightness, he had no idea what gigantic field he was about to open. Since then, astronomers have learned that many red giant and supergiant stars like Mira — perhaps even *all* of them — vary by several magnitudes over a period of weeks or months. Mira will be visible in the heart of Cetus all during autumn, but we won't tell you whether it is at minimum, maximum, or somewhere between. If we did, the knowledge might affect your observations.

With a 332-day-period, Mira varies slowly enough that you should not observe it more than once every two weeks. By choosing two comparison stars, one brighter and one fainter than the variable, estimate Mira's brightness relative to these stars. Each time you examine the star, try not to notice what you logged before, so as not to prejudice your results. By the time Cetus vanishes into the evening twilight, look over the record you've made — Mira's behavior ought to stand out clearly.

Now let's move eastward into Perseus, where an old favorite of mine lurks. **S Persei** is a red star with a slow and not very regular period that lies almost within the field of the exquisite Double Cluster. Its striking red color makes this star easy to see, but since most people's attention is drawn to the glory of the cluster, they probably miss seeing the "side show" nearby. Because S varies only slightly, estimate it but once a month.

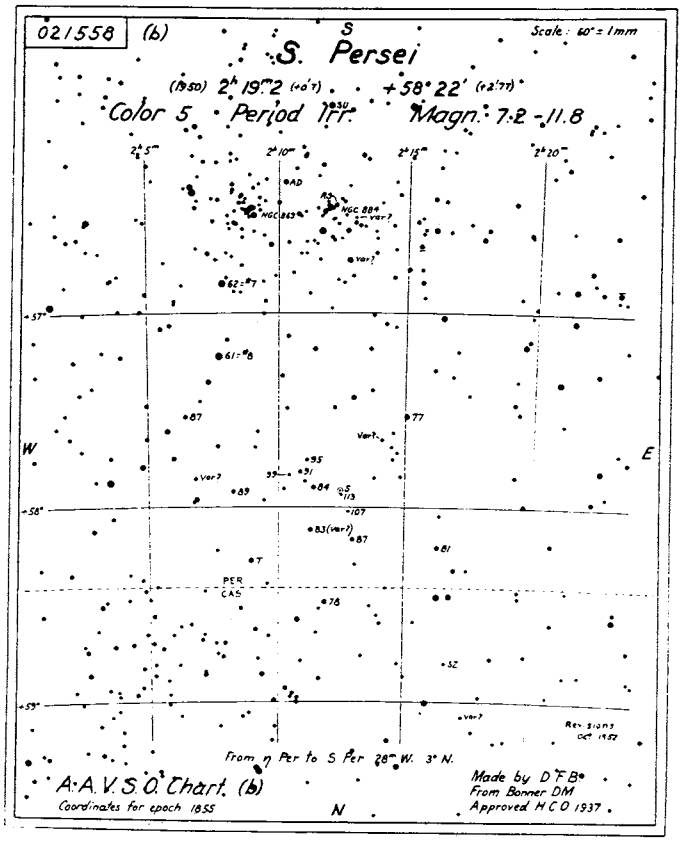
RU Lupi?

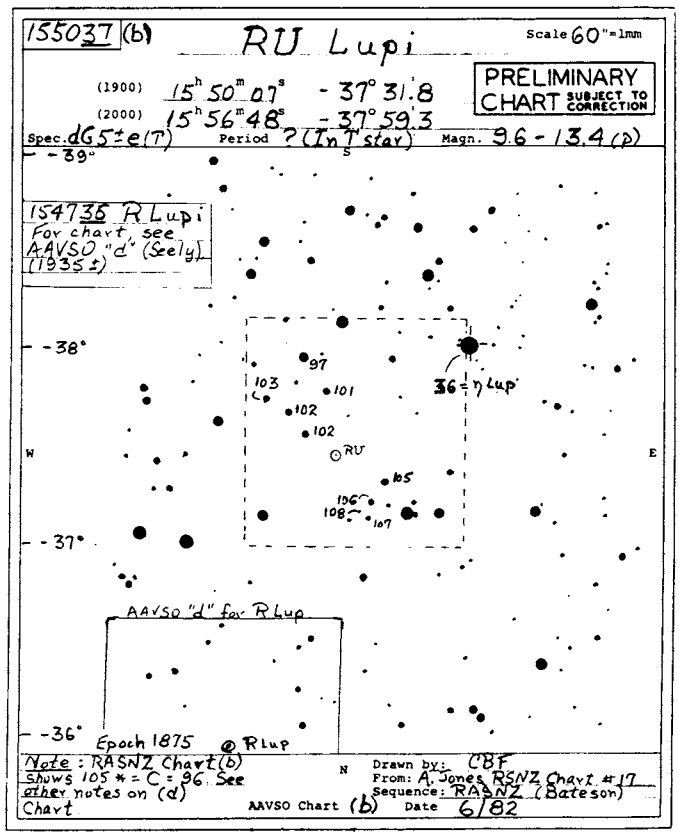
Some time ago, I put this question to the readers of the old *Deep Sky Monthly* and the response was unanimous: deep sky observers are totally uneccentric — perfect circles not elliptical in any way. Everyone *else* is lupi! But yes, there actually is a star called **RU Lupi**. It is one of two strange "InT" nebular stars we'll explore in this column. These are stars that appear to be surrounded with dusty gas and which often have short (several weeks) fluctuations superimposed on longer (500 day) variations. Even though RU is a nebular variable, it may also be an eclipsing binary, as variations of 3.5 to 3.8 days have been observed.

RU Lupi lies deep in the southern hemisphere — in fact, it's invisible unless you can see stars down to −40° declination — so you'll have problems finding it. Moreover, the AAVSO has no official comparison sequence for it either. But if you can find it, choose five stars close in brightness and position to the variable, label them "a" through "e" and judge RU's relative brightness to any two of these stars in your sequence. If it is midway between a and b, then write the notation "a1v1b". If it is three fourths of the way to b from a, write "a3v1b", and so on. Known as the fractional method, this approach is popular in Britain, and is useful for stars without comparison sequences.

In the heart of the Hyades Cluster lies an important variable whose behavior is similar to Ru Lupi's. T Tauri is a young star whose uncertain variations offer both long-term variability and short-term changes — neither of which can be predicted. T Tau is a star which should be estimated at least once a night, and should you be out for several hours, try looking at it once an hour. If you're lucky, you may possibly notice changes of up to a quarter of a magnitude.

But this star does more. On one night


021558 (b)
S Persei
Scale: 60' = 1mm
(1950) 2h 19m2 (+0'1) +58° 22' (+2'7)
Color 5 Period 1rr. Magn. 7.2 - 11.8
W
E
From η Per to S Per 28° W. 3° N.
A.A.V.S.O. Chart (b)
Coordinates for epoch 1855
N
Made by D F B
From Bonner DM
Approved H C O 1937


155037 (b)
RU Lupi
Scale 60" = 1mm
PRELIMINARY CHART SUBJECT TO CORRECTION
(1900) 15h 50m 07s - 37° 31.8
(2000) 15h 56m 48s - 37° 59.3
Spec. dG5+e(T) Period ? (In T star) Magn. 9.6 - 13.4 (p)
154736 R Lupi
For chart, see AAVSO "d" (Seely) (1935±)
36 = η Lup
AAVSO "d" for R Lup
Epoch 1875 @ R Lup
Note: RASNZ Chart (b) shows 105 * = C = 96. See other notes on (d) Chart
Drawn by: CBF
From: A. Jones RSNZ Chart #17
Sequence: RASNZ (Bateson)
AAVSO Chart (b) Date 6/82

S Persei (above left) lies about a degree and a half north of NGC 884, the eastern of the two star clusters that make up the Double Cluster in Perseus. It has a striking red color. RU Lupi (above right) varies in a complicated fashion: irregular fluctuations are superimposed on a longer, more regular period. Note that the AAVSO chart is preliminary; some comparison star magnitudes may be in error. Charts courtesy AAVSO.

I watched it perform some strange celestial acrobatics. I had begun the evening by observing **T Tauri** and the nearby Orion variables. Things went normally for about 15 minutes, during which I estimated T Tau and then moved toward Orion to spend ten minutes marking down magnitudes. Then I went back to Taurus. I noticed that T had abruptly brightened by a fifth of a magnitude — something I was not prepared for in so brief a time.

I was about to record its brightness when, on checking the star again, I noticed that it had risen still more. Feverishly, I wrote both estimates and within the minute, the star faded again. I settled down to watch and record T Tauri's flickers every 60 seconds.

How I wished someone else could have been observing them! What if this variation was not real? What if my eye, and not the star, was playing tricks on me? I turned my attention more closely to the comparison stars I was using, and to other stars in view. They appeared to be shining steadily in a night of pretty good seeing, yet there T Tauri was, slowly flickering like a candle in a breeze. Continuing my estimating process for an hour or so until the star seemed to quiet, my mood swung from ebullient to frantic. Either I'd been witness to an exquisite display of nature — or I needed a new set of eyes instead.

The next night I tried again, but T Tau was back to its usual self, and never again did I see a repetition of that night's remarkable behavior. I sent the observations in with my monthly report to the AAVSO, but because no one could confirm it, I am still uncertain how much of what I saw was real. The Orion variables are known to flicker over a few minutes, but variation over a minute or less is rare, to say the least.

In T Tauri's field, you'll find the stars noted at magnitudes 9.3, 9.8, 10.2, and 10.8 are the most useful comparison stars for observing this strange variable. And always keep to the same set of comparison stars when you observe: if you change your comparison standards, you may also unwittingly change your estimates. Keep everything as constant as possible, and leave the variations to the variable.

Camelopardalis Quartet

Now let's move north into Camelopardalis, whose circumpolar location makes it easy to observe almost the year round. In fall, the string of fascinating variables that it harbors rises high enough to be easily visible. The most exciting is **Z Cam**, which leads a subclass of dwarf novae whose eruptive behavior has a special quirk: on the way down from maximum, Z occasionally stalls — sometimes for weeks, more often for months, and during the latter half of the 1970s, for *years*. The duration of the standstills are as unpredictable as when they will take place. Normally, one estimate per night is appropriate for this variable, except when it is going into outburst, in which case make a reading every hour.

Nearby is **X Cam**, a Mira-type star with a period of only 143 days — short enough to detect changes in a week. Such a star enables you to study the behavior of the Mira-types in accelerated time, since you can get more than two complete lightcurves in a single year.

Camelopardalis has two more stars of interest. **RR Cam** is an M6 star whose semiregular variations range between 9.8 and 11.2; you should measure it once a month. (It varies somewhat more regularly, and more visibly, than S Persei, discussed earlier.) And lastly, we end with R Cam, the first variable to be discovered in this constellation. As this star is a typical Mira-type with a seven-month period, we note that we have come full circle.

Rt. 7, Box 414
Tucson, AZ 85747

Scanning the Literature

April — June 1984

One of the advantages of astronomy from high-altitude observing sites is that atmospheric turbulence, or seeing, is often small compared to lower elevations. Laird A. Thompson has shown what such wonderful skies can do for you in "High Resolution Imaging from Mauna Kea: Cygnus A," published in the *Astrophysical Journal Letters* for 15 April (**279**:L4). He used a CCD camera on the University of Hawaii's 2.2-meter telescope, and equipped the scope with a newly-designed automatic guider that compensates for much of the small image motion due to seeing.

The strong radio source Cygnus A is thought to be some sort of an extragalactic object far beyond the Milky Way. In the past, the best photos of Cygnus A have shown a superficial resemblance to NGC 5128, the bright active galaxy (and radio source) in Centaurus. The improved resolution of the new imagery indicates that Cygnus A is probably a pair of colliding galaxies. Even this interpretation is unclear, however, as several condensations appear. From photometric analyses of the digitized photos he took, Thompson derives a V magnitude of 17.3 for the object within a 5 arcsecond square. Would 24-inch owners care to try for this one visually?

As reported here in *Deep Sky* #6, the general consensus on the nature of quasars is that they are luminous centers of otherwise normal galaxies. Direct evidence of this is presented by Canadians J.B. Hutchings, D. Crampton, and Bruce Campbell, in "Optical Imaging of 78 Quasars and Host Galaxies," *ApJ* **280**:41, 1 May. In all but seven of the QSOs in their sample, they observed "fuzz" which presumably represents the galaxy whose nucleus is the quasar. The appearance, magnitudes and colors of the fuzz suggest that over 40% of the underlying galaxies have the characteristics of spirals. The authors found no positive evidence for elliptical host galaxies. A third of the QSO hosts appear to be interacting with another galaxy, and a quarter are in small groups or clusters of galaxies (all these portions overlap to some extent).

A major project in extragalactic astronomy is "The Clusters of M33", by J.G. Cohen, S.E. Persson, and L. Searle (*ApJ* **281**:141, 1 June). From spectrophotometric observations with the 5-meter Hale telescope, the authors synthesized data in the Thuan-Gunn photometric system, which can measure the ages and metal abundances of star clusters. The spectrophotometric scans were also used to measure radial velocities and metal abundances for some of the clusters directly from the absorption lines in their spectra. M33 appears to contain clusters of several kinds: luminous objects like the brightest young open clusters in the Milky Way, rich intermediate-age clusters similar to objects in the Magellanic Clouds, and "true" globular clusters as found in our Galaxy and in M31. The spread in age is like that of clusters in the Magellanic Clouds, and clearly unlike that of the Milky Way or M31. In the limited sample, the authors found no old open clusters like M67 or NGC 188, and the four globular clusters observed are all more metal-poor than any in the Milky Way. Evidently the star-forming histories of galaxies in the Local Group are dramatically different.

Palomar Observatory

M33: *clusters like the Magellanic clouds.*

In "A New Color-Magnitude Diagram for the Peculiar Star Cluster E3 = C0921-770," *P.A.S.P.* **96**:406, June, a group led by James E. Hesser presents information about a faint, sparse globular cluster in the far southern sky. E3 was discovered in 1976 on plates taken with the European Southern Observatory's 1-meter Schmidt at La Silla, Chile. The new photometry of the cluster shows that it is a globular, though it appears no richer than the richest open clusters. Unlike most globulars, this object has very few stars in its giant branch: it is deficient by a factor of ten compared to well-known clusters like M3. E3's color-magnitude diagram shows a number of "yellow stragglers," stars cooler and brighter than the brightest main-sequence stars in the cluster. These stars may or may not be cluster members, but if they are, they pose difficult problems for well-established ideas on stellar evolution! The cluster's distance is at least 8 kiloparsecs, and its brightest stars are about magnitude 15.

A little closer to home, a number of studies of stars similar to the Sun are being conducted by groups of astronomers at Mount Wilson, Harvard, and elsewhere. The aim is to determine how stellar activity — sunspots, flares, and magnetic fields — correlates with the age, temperature, rotation and chemical composition of stars, and, ultimately, where our Sun fits in amongst stars. One measure of stellar activity is the amount of light emitted by flares and plages in the chromospheres of stars, which on the Sun occur above sunspots. In these studies, this emission is being observed in the H and K lines of calcium in the violet end of the spectrum. The emission varies (from stars and on the Sun) not only as surface features rotate in and out of our line of sight — leading directly to a rotational period for a star — but also over a period of years as a star follows a cycle of increasing and decreasing activity much like the solar sunspot cycle. The stars being studied by this group include ones in the Hyades and Coma clusters as well as bright double stars such as Xi (ξ) Bootis and 61 Cygni.

Rotational periods for a number of solar-type field stars is presented in the April 15th *ApJ* (**279**:763), members of the Harvard and Mount Wilson groups — led by Robert Noyes — present rotational periods for a number of solar-type stars. From data on forty-one stars, they find that the average level of chromospheric activity, as measured by the HK emission, correlates well with the rotation rate and spectral type of the stars. But while faster rotating (generally young) stars have higher HK emission, cooler slow-rotators can also show strong activity.

The Pleiades cluster has recently attracted attention. Photometry and spectroscopy of some of its late G and K stars, which are somewhat cooler than the Sun, has been done by some of the Harvard group led by John Stauffer (*ApJ* **280**:189 and 202, 1 May). The Pleiades are very young, only one one-hundredth of the Sun's age. The solar-type stars in the group have just formed and come onto the main sequence, and are rotating very rapidly

— some have periods of several hours. At least some of these stars are heavily spotted, causing them to vary in brightness. Rotational periods determined using spectroscopy match the periods of brightness variation found from photometry done a few years ago by van Leeuwen and Alphenaar at the European Southern Observatory.

While the ages of stars in clusters can be determined accurately from theoretical considerations, finding the ages of isolated field stars is not so straightforward, but can be estimated from multicolor photometry. Ages for many stars which occur in pairs are given by Doug Duncan of Mount Wilson in "Ages of Solar-Type Stars." (*AJ* **89**:515, April).

Four interesting articles about double stars and their orbits have recently appeared. Measures of a number of relatively wide pairs (2″ to 10″) are given by D.J. Macconnell in "Micrometer Observations of Double Stars. II." (*AJ* **89**:876, June). He observed mostly with the 26-inch refractor at the Venezuelan National Observatory.

In "Micrometer Measures of Double Stars at Lick Observatory", *P.A.S.P.* **96**:174, February, French double star observer and author Paul Couteau presents some data of his own. The results are from a summer's work with the 36-inch refractor on Mount Hamilton. Nearly all the doubles, some of which were discovered by the author, have separations of less than half an arcsecond.

A powerful and fast technique for making double star measures is speckle interferometry. Harold A. McAlister's group at Georgia State University is perhaps the most active in making such observations. The latest installment of their results gives several measures for each of some hundreds of pairs ("Speckle Interferometric Measurements of Binary Stars. IX." *ApJ Supplements* **54**:251, February). Again, the observed stars are mostly subarcsecond pairs, down to only a few hundredths of an arcsecond. At 0.054″, Beta (β) Coronae Borealis is typical — it was previously resolvable only by spectroscopy or during lunar occultations. Orbits for such pairs can often be made in a decade or less, so rapid is their motion, while the average wider pair requires several *generations* of observations (and observers!) before a sufficient arc of the orbit is covered.

Lick Observatory

NGC 253: ***New photometric sequences for Sculptor galaxies.***

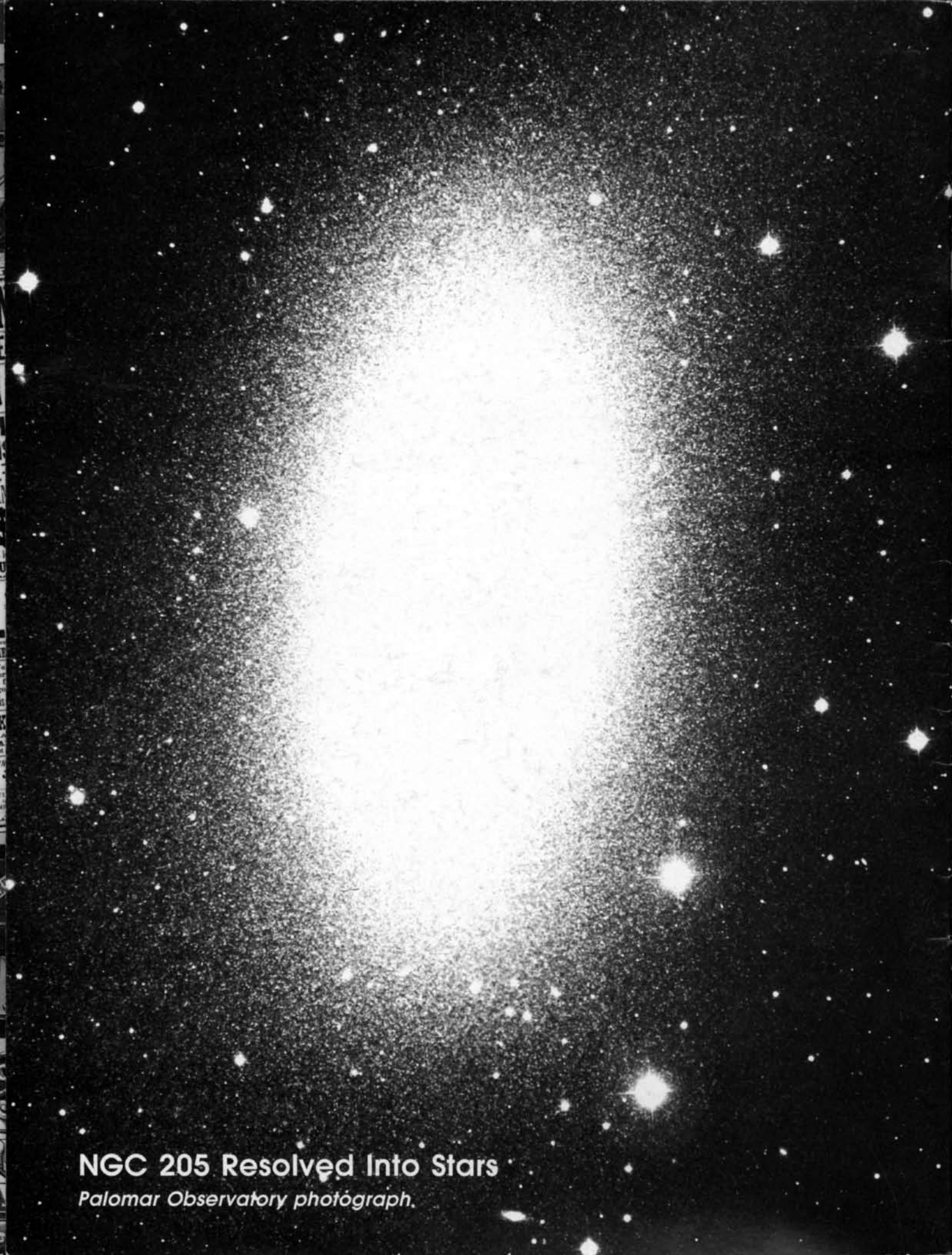
Yet one very close pair that has been successfully observed is Kuiper 75, a ninth magnitude double in Ophiuchus. W.D. Heintz summarizes recent orbital data on this pair in "The Rapid Visual Binary Kpr 75" (*P.A.S.P.* **96**:439, June). Famous for 50 years as the binary with the shortest period, only about 20 *months*, Kuiper 75 consists of two cool M-type dwarfs, and at least one is a flare star. But at a nearly constant separation of just 0.21″, the pair can be resolved only in large instruments. Some long-term photoelectric photometry could determine something about the flare star's behavior: why doesn't an amateur photometrist "adopt" this star for a few months?

Both astrophotographers and visual observers will be interested in "Photoelectric UBVRI Sequences in the Sculptor Group Galaxies: NGC 45, NGC 55, NGC 247, NGC 253, NGC 300, NGC 7793" by Gonzalo Alcaino and William Liller (*AJ* **89**:814, June). Alcaino and Liller provide measures for typically a dozen stars around each galaxy, ranging from V magnitude 8 or 9 down to 16 or fainter. These will help supernova searchers to identify a new star and easily and confidently estimate magnitudes. Beautiful ESO 1-meter Schmidt photos accompany the article to identify the measured stars.

Brian Skiff
421 West Aspen
Flagstaff, AZ 86001

The Pleiades: ***young, spotted solar-type stars with rapid rotational periods.***

Lick Observatory



NGC 205 Resolved Into Stars

Palomar Observatory photograph.